NATURE

No. 4099 SATURDAY, MAY 22, 1948 Vol. 161

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Telegrams : Phusis Lesquare London
Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone : Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, inland or Abroad

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NATIONAL PARKS IN BRITAIN

THE intimation by the Lord President of the Council in the House of Commons on April 29 that the Government has at long last agreed in principle to establish a Nature Conservation Board and a Biological Service under the auspices of the Agricultural Research Council is both welcome and reassuring. It is not merely that the scientific community has the satisfaction of seeing the principal scientific recommendations of the Conservation of Nature reports accepted. By implication, some effective action must be contemplated in regard to Nature reserves, and possibly national parks also, if the proposed Biological Service is to have an adequate field of work. The statement was the more welcome because earlier replies, given in the House of Commons on April 8 and during a debate on the same day in the House of Lords, gave the impression that the Government was hesitating to take a decision.

Following its recommendation that the prime charge of national parks should be given to a specific central authority, in the form of a National Parks Commission, under the parliamentary responsibility of the Minister of Town and Country Planning, the National Parks Committee recommended that the committee set up for each national park should be designated the local planning authority for that area. The park committee would thus replace the county council or councils in whose area the park lay for the purposes of planning and controlling development, although any important conflict between local and national interests which the park committee could not resolve would be referred to the Minister for his decision. The Hobhouse Report further recommended that the chairman and half the other members of each park committee should be appointed by the National Parks Commission and the other half by the county council or county borough councils whose administrative areas fell wholly or partly within the national park.

Uneasiness, not to say dissatisfaction, has already been manifested in the frequent disputes concerning the land requirements of the Services over the Government's failure either to appoint a National Parks Commission or to take any decision concerning the areas to be designated as national parks. It now appears that the Government has decided on the appointment of a National Parks Commission ; but the position with regard to the Hobhouse proposals on local organisation and planning still awaits clarification. Lord Henderson's statement in the House of Lords was not altogether clear ; on the ground of the general planning system of the country being in a state of evolution and of the much higher standard of planning anticipated, especially in rural areas, under the new planning authorities set up under the Town and Country Planning Act, 1947, he seemed to commit the Government to accepting the county councils as planning authorities responsible for the national parks, to the exclusion of any National Parks Commission which may be established.

It will be recognized, as was emphasized in the debate, that under the Hobhouse proposals some counties would lose a third or more of their area—one of them more than three-quarters; indeed, some ten per cent of the total area of England and Wales would be affected. It will never be easy to strike the right balance between the different interests—even different national interests—concerned; but the whole trend of the debate in the House of Lords indicated the immense amount of goodwill and the general desire to reconcile interests which might sometimes clash. But no one who has followed, however superficially, the discussions in recent years on local government reform will be satisfied that, if a National Parks Commission has no hand in the planning of these areas, there is no danger that some county councils will allow particular local interests, whether farming, mining or building, to destroy altogether the scenic and amenity interest which is the mainspring of the whole idea of national parks.

Lord Henderson's inability to forecast either the date or the extent of future legislation on this matter was very disappointing in spite of his reference to the hope expressed by the Minister of Town and Country Planning that it would be possible to introduce such legislation during the life-time of the present Parliament. His statement would have been more convincing had he shown some appreciation of the fact that, in making its proposals, the Hobhouse Committee very clearly recognized that it is essential to preserve and to extend the means for the expression of local views and for maintaining local interest. The conception on which its policy and proposals for national parks are based is dynamic and not static, as Lord Henderson implied. The Hobhouse Committee, while emphasizing the importance of national control and a national policy, and that the central management and development of national parks and Nature reserves must be planned from the start in adjustment with other essential interests in the land, such as agriculture, forestry, water supply, communications and building, was equally insistent on the importance of enlisting local knowledge and experience, and encouraging and maintaining local interest and co-operation.

In the absence of any indication that the Government intends to give a National Parks Commission real authority as distinct from merely advisory functions, there is every reason to believe that the county councils will be so firmly entrenched in the proposed national park areas that it will be difficult, if not impossible, to secure for any such Commission a preponderant voice in the planning of the parks. Harm may already have been done to areas of exceptional beauty that will be beyond the power of the wisest and ablest management to repair. Furthermore, if the Minister of Town and Country Planning deals with the whole matter under the Planning Act, as Lord Henderson more or less implied he proposes to do, there will not be unity of control even within such important areas as those proposed for the Lake District and the Peak, which are themselves within the boundaries of several planning authorities.

It is clear from this debate that a coherent system of national parks in Britain is by no means assured, and that little effective may remain of the recommendations which last year received such a friendly welcome from public opinion. No Government could have had at its disposal a greater volume of expert advice and of objective study in these matters. In spite, however, of something approaching its intense activity in the nationalization of industry, the Government is singularly indifferent to the dangers of drift and of unco-ordinated action in matters affecting the utilization of the land, and seems reluctant to insist on the national control that is imperative and has been urged by such impartial authority. Even in the matter of Service land requirements, the Government has consistently ignored the need for providing some means for overall review and for avoiding piecemeal encroachment on other national interests. Both in the White Paper on the "Needs of the Armed Forces for Land for Training and Other Purposes", and in debates in the House of Commons on specific proposals, Government spokesmen have studiously avoided giving any positive reply to direct questions regarding national parks and National Trust property.

The case for a National Parks Commission with full statutory powers, and the importance of the time factor in this connexion, was ably put by Lord Merthyr in opening the debate. Quite apart from the question of Service lands, mineral developments, afforestation and hydro-electric power or water-supply developments, it may well be too late, as Lord Merthyr observed, if we wait until the building restrictions are lifted before establishing national parks. Lord Merthyr was ably supported by Lord Samuel and others, and while Lord Rochdale and Lord Roborough in particular advocated use of the planning organisation laid down in the Town and Country Planning Act, 1947, it was generally recognized that means must be found for securing the co-operation of local communities and authorities in order to achieve the national purpose, whatever degree of authority is given to a National Parks Commission.

Some of the criticism of the Hobhouse Reports as well as of the Huxley Report on the conservation of Nature in England and Wales and the reports of the Scottish National Parks and Wild Life Preservation Committees suggested that the speakers have not studied these reports with sufficient care. Despite some differences in several recommendations, they all agree as to the necessity for a national policy and control, and that a national parks policy must be considered in relation to other national interests affecting the use of the land and the exploitation of natural resources. Nor could the importance of securing local understanding and support be better urged than throughout the reports. Lord Robinson, and with him Lord Hylton, may have been right to suggest in the debate that further consideration should be given to the use of the land for agriculture and other purposes in our present economic position; but the suggestion that the Hobhouse Committee had overlooked such considerations, and had taken a

static view of the question likely to lead to sterilization of the areas to be allotted as national parks, is surely inaccurate.

What is clear from the debate, as from the reports, is that the balance between national needs in respect of land for agriculture, water supply, afforestation, minerals and the like must be struck at the national level, and not piecemeal by either departmental, local or sectional interests. The proposed National Parks Commission can make a vital contribution in arriving at that balance, from the point of view of amenities, the preservation of wild life and scientific interests. Furthermore, the whole trend of Lord Roborough's remarks indicates, as Lord Methuen quickly noted, that even in such an extreme case as that of Devon and Dartmoor, there should be little difficulty in reaching an agreed solution under the Hobhouse Committee's proposal, and securing the efficient and whole-hearted co-operation of the county council in the planning and management of the national park.

Nothing in the debate, therefore, warrants further delay on the part of the Government in the creation of a National Parks Commission or in determining the areas of the parks themselves. On the contrary, the debate gave clear warning to the Government of the dangers of delay, and of the shock that public confidence in its good faith in this matter has already received. The Government has taken care in many matters to provide itself with expert and impartial advice. Failure to act on such advice, above all in matters which are not the subject of party controversy, and where, as in the matter of the Huxley Report and those of the Hobhouse Committee, inaction itself prejudices the issue, must react adversely on the understanding and good relations which the Government has often been at pains to foster with the scientific community.

COSMIC RAYS

Cosmic Rays

By L. Jánossy. (International Series of Monographs on Physics.) Pp. xiii+424. (Oxford: Clarendon Press; London: Oxford University Press, 1948.) 35s. net.

THE study of cosmic rays is one to which scientific men in very many countries have contributed materially. It is therefore fitting that the book under review should have something of an international character: its author, Prof. L. Jánossy, came to Britain from the Continent, and spent several years at Manchester before taking his present post at the Dublin Institute for Advanced Studies.

Most of the book was written during the last years of the War, when, because of the slowing down of cosmic-ray research, a comprehensive view of the whole subject was more readily attainable than in more normal times. The author has given a reasonably complete picture of the state of the subject as it then was. All the material to be found in reports and books published before the War is here also: experimental work on transition effects, showers, cosmic rays at great heights or depths, and the influence of the geomagnetic field. In addition, more recent work is also reported, such as that on the properties and life of the meson, and on extensive and penetrating air showers. The recent work at Bristol, using photographic methods to investigate meson behaviour, is briefly reported in an appendix.

The book is an experimenter's book; experimental physicists would, however, have grounds for grievance if the impression were given that it was simply an experimenter's book. While much time is spent on the observations, and an important chapter is devoted to experimental technique, a large part of the book is devoted to the theory needed in interpreting the observations. A relativistic theory of collisions is given, for, without going into relativity, even a qualitative interpretation of cosmic rays is impossible. In discussing radiation, semi-classical methods are used: where quantal results are needed, they are quoted without proof, with an indication of their relation to the corresponding classical results. A few hints on meson theory are given, but only enough to whet the appetite. The theory of cascades is discussed in detail: in this, the author plunges fearlessly into Laplace transforms, and the evaluation of complex integrals by residue and saddle-point methods. In the chapter on geomagnetic effects, Störmer's theory of the forbidden cone is set out; and statistical ideas necessary in interpreting the experiments are explained in another appendix.

But theory to Jánossy means a useful adjunct to experiment, not speculation. He comes closest to speculation in introducing the sun's magnetic field. In so far as the book has a guiding thread running through it, it is that the primaries giving rise to observed cosmic rays have a momentum spectrum given by an inverse power law, cut off at the low-energy end by an agency supposed to be the sun's magnetic field. But the inverse power spectrum cannot, in any event, extend to low energies, since it would give an infinite number of low-energy particles, and one wonders whether the energy cut-off need be so sharp as Jánossy suggests; and the properties and precise magnitude of the sun's field are still open to some doubt.

A book discussing so wide a range of subjects as the present cannot fail to be difficult. Unfortunately, the author has made it harder than need be. The style is very variable: while fluent in some places, in others it is disjointed and crabbed, and there is little to suggest the excitement which first attended the discovery of the positive electron and the meson. Needless repetitions abound: the first (historical) chapter is the worst in this respect. The author seems not always clear how much prior knowledge to assume; the first chapter is scarcely intelligible unless one already understands something about transition effects, coincidences, Geiger counters, positive electrons and mesons, all discussed in detail later; while in the middle of Chapter 6, after already giving long chapters on the general properties of cosmic rays and on meson decay, the author suddenly says, in a Micawber-like burst of confidence, "Photographs . . . show clearly that the cosmic rays consist of two groups of particles: (1) penetrating particles, (2) electrons". Altogether, one feels that the book could have been improved considerably by due care in arrangement.

Nevertheless, the author has taken great pains to ensure that the book is as comprehensive as possible, and has succeeded in bringing together and correlating a large mass of useful information. There is little doubt that it will be indispensable to research workers, and will serve to stimulate further the growing interest in the subject. T. G. Cowling

THE STORY OF JADE

Adventure in Jade

By James Lewis Kraft. Pp. ix+81. (New York: Henry Holt and Co., 1947.) 3.50 dollars.

JADE was used for ornaments and tools by the native peoples of Mexico, Central America and Peru, by the Indians of British Columbia, and by the Eskimos. The source of the jade was something of a mystery. In the absence of any known sources—either of nephrite or jadeite—on the American continent, it was supposed, up to ten or twenty years ago, that the jade used by the Eskimos and also that of the Maya and other Central and South American peoples had been brought in from Asia. Of late years, however, some localities for jade have been found in the United States, and Mr. J. Lewis Kraft tells the story of these discoveries.

The subject of the book is of particular interest to Americans not only because of this problem of the origin of the ancient worked articles of jade, but also because there has grown up in the United States a widespread and very active interest in all kinds of semi-precious stones. All over the country there are now local societies and clubs the common interest of which is the search for semi-precious stones and the fashioning of these stones into cabochons and faceted stones for collection specimens or jewellery. Many amateur lapidaries have acquired great skill at this work, and Mr. Kraft is one of these.

His book is not deeply scientific. It is the story, simply told, of how a very busy man found an absorbing interest in jade and the fashioning of it with his own hands into pieces for his collection, presents for his friends, and jade rings as awards for merit to his "fellow workers at the Company". There is much of legend and folk-lore in the book and tales of miners and prospectors and their finds. The author has encouraged or persuaded several prospectors to search for jade, giving them fresh clues to follow or urging them to penetrate to such remote regions as Jade Mountain in Alaska, discovered by George M. Stoney so far back as 1886 but scarcely ever visited since. In Wyoming, nephrite was found near Lander in 1931, and two other occurrences in that State are recorded in this book. An immense boulder weighing 2,490 lb. from Crooks Mountain, fifty miles south-west of Lander, was removed under the author's supervision, transported to Chicago and presented to the Natural History Museum there in 1944.

Ten years ago Pabst's "Minerals of California" contained no record of jade; now the author describes four localities in California from which he has obtained good nephrite. The story of one of these finds reads like the discovery of the first diamond in South Africa. In 1880 a hunter after sea lion entered a cave on the coast of Monterey County. Finding the cave-floor covered with shining green pebbles, he took some home. Fifty or sixty years later a visitor to the hunter's home noticed the children, grandchildren of the hunter, playing with the pebbles. Being interested, he took some back to Stanford University. They were identified as nephrite, and afterwards an enterprising search resulted in the rediscovery of the cave and the recovery of some of the nephrite pebbles and boulders which strew its floor.

It seems that at all these Californian localities the jade is nephrite, so the source of the jade used by the Mexicans, which is largely jadeite, is still to be found. One feels sure that Mr. Kraft will leave no stone unturned until he solves this problem too.

Special care has been taken in the design and type for this book, and the result is a fine example of modern printing. All the royalties will go into a charitable trust.

PHYSICAL PLANNING IN THE SOUTH-WEST OF ENGLAND

Devon and Cornwall

A Preliminary Survey. A Report issued by the Survey Committee of the University College of the South-West, Exeter. Pp. iv+318. (Exeter: A. Wheaton and Co., Ltd., 1947.) 31*s.* 6*d.* net.

IN the provisions of the Town and Country Planning Act, 1947, Britain is committed to the planning of the use of every acre of its land surface, and the county authorities become the primary planning authorities. They are required to put forward their proposals for the approval of the Minister within a brief space of time, and there is a very real danger that far-reaching decisions on policy will be taken with a totally inadequate foundation of factual knowledge. It is therefore of the utmost importance that surveys such as this volume on Devon and Cornwall should be undertaken and made available at the earliest possible opportunity. There is an obvious advantage in such work being undertaken by independent groups with no preconceived points of view and with no axe of their own to grind.

Like the survey of Herefordshire previously issued by the West Midland Group, this survey of the south-west has been undertaken by a representative survey committee, headed by the principal of the University College of the South-West, Exeter, and including both members of the College and experts from outside. The result is a comprehensive account, well documented, adequately provided with statistical information and with a number of excellent maps and diagrams covering the two counties. Published or other documentary material has been supplemented from the results of field surveys, notably one carried out by groups from the College in 1944. Particularly instructive are the attempts to show on a cartographical basis the spheres of influence of the urban centres in these two rural counties. In places the point of view is that of the townsman visiting the country rather than that of the dweller in the village, and it would be possible to criticize in detail some of the maps, as well as some of the information, particularly regarding that rather remote area of north-east Cornwall and adjoining parts of Devon, where the text and maps suggest a stagnation of social life rather far from the experience of those who know the area intimately from within.

There is no indication as to the authorship of the individual sections, and one wonders whether the general conclusions of the excellent first section on population are those of the whole group or of the individual responsible, especially when one reads, "The whole emphasis should be on providing the country with the amenities of the town". Further, the separate contributions tend to be distinct essays rather than a connected whole. Whereas some summarize published information, others contain

much original material. The section on climate is inadequate; that which deals with fisheries is excellent in its scope and treatment, though it is difficult to understand why there should be no recorded landings of fish at Bideford, which in pre-war years was a favourite resort on market days of those who bought their fish fresh from the fishermen on the quayside.

Apart, however, from such minor criticisms, there can be nothing but praise for a volume which embraces such a wide field and which presents in small compass a collection of facts absolutely invaluable and essential for all planning work.

L. Dudley Stamp

ALGEBRAIC GEOMETRY

Foundations of Algebraic Geometry

By Prof. André Weil. (American Mathematical Society: Colloquium Publications, Vol. 29.) Pp. xix+288. (New York: American Mathematical Society, 1946.) 5.50 dollars.

ALGEBRAIC geometry, in spite of its beauty and importance, has long been reproached for lacking proper foundations. Great discoveries have been made, especially in Italy, by the intuition of a number of gifted workers, whose insight had been cultivated by a careful study of special cases. But the time for placing the subject on a firm foundation is long overdue, and the delay is seriously hampering progress. For the last twenty years a few geometers, such as Severi, van der Waerden and Zariski, have made important contributions towards this end. Now Prof. Weil has given a connected and comprehensive account of his own and other researches, sufficient to justify the use of intersection-multiplicities, which play such a large part in recent geometry, especially in Italian work. The book is not easy reading, especially for those to whom geometry is synonymous with space-intuition. At a first glance the reader might imagine that it is a treatise on something like abstract algebra. Indeed, the author warns the reader that it is necessary to have a good elementary knowledge of abstract fields and of other topics that will be found in van der Waerden's "Moderne Algebra". Apart from this the book is self-contained, and its subject is not abstract algebra, but what might be called abstract geometry.

The first three chapters are preliminary; they state and prove all the purely algebraic results required. In particular, Chapter 3 gives the crucial theorem on the multiplicity of a proper specialization. Geometric language is introduced in Chapter 4, which deals with algebraic varieties in affine spaces. Chapters 5 and 6 contain a careful and detailed treatment of intersection-multiplicities.

Chapter 7 extends the definitions and results of previous chapters to 'abstract varieties'. It also translates the main results of intersection theory into a new language, the 'calculus of cycles', which is particularly well adapted to applications. The author points out the confusion that has arisen by the use of ambiguous terms, and endeavours to do away with this by introducing new terms such as 'bunches of varieties' and 'cycles' instead of the single term 'reducible variety' used in two different senses. The term 'variety' is reserved for 'absolutely irreducible algebraic varieties'. An algebraic calculus of cycles can then be developed, closely analogous to the algebra of homology-classes as used in modern topology.

Chapter 8 gives a detailed treatment of the theory of divisors on a variety. Chapter 9 contains general comments on the preceding work, formulates problems, some of considerable importance, and in some cases makes suggestions which may lead to their solution.

H. T. H. Piaggio

PRIVATE LIVES OF THE ALCHEMISTS

The Alchemist in Life, Literature and Art

By Prof. John Read. Pp. xii+100+30 plates. (London and Edinburgh: Thomas Nelson and Sons, Ltd., 1947.) 10*s.* 6*d.* net.

THE practical operations of the alchemists and their main theoretical beliefs are familiar, in outline at least, to every student of chemistry. The chemical historian may be as familiar with alchemical technique and ideas as the average chemist is with the modern technique of his science. Few, however, have any clear picture of the alchemist as a human being, an individual with a private as well as a professional life. This picture has been skilfully and entertainingly drawn by Prof. John Read in the book under notice, and there are not many, either men of science or laymen, who will not derive both pleasure and profit from reading this scholarly little work.

As the title indicates, Prof. Read draws his material from three main sources. First, there are alchemical biographies, unfortunately all too few, such as Thomas Norton's "Ordinall of Alchimy" and Simon Forman's personal diary. Second, there are the artists who sought inspiration in alchemical themes and have left us invaluable records of the appearance of alchemical laboratories and those who worked in them. Outstanding among these was David Teniers the Younger, to whom the author appropriately dedicates his book. Finally, there are the writers who introduce alchemists and their assistants as characters in their works. Few modern chemists would regard Chaucer's "Canon's Yeoman's Tale" as an important piece of alchemical literature without Prof. Read's skilful analysis and apt quotation. He shows that, in fact, this tale contains a vivid picture of both the charlatan alchemist—the mere puffer or bellows-blower—who will stoop to selling a fake formula to a credulous priest, and also of the genuine alchemist who, even if his ideas are coloured by the hope of discovering the Philosopher's Stone, is, in fact, a serious seeker after knowledge.

As we may expect, the alchemist in his private life conformed to no particular type in mind or body. We have the libertine Forman, for ever guiding his amorous ventures by reading special mystical meanings into the events of his daily life; the cheating Subtle, in whom Jonson holds up to shame and ridicule the alchemical charlatans of his time; the melancholy and frustrated beings portrayed by Dürer and Teniers; the fanatic in threadbare clothes with complexion of "wan and leden hewe" after long hours at the furnace, ignoring the pleas of his starving family; and that fantastic international adventurer Seton, the "martyr of alchemy".

Publisher and author are to be congratulated. After several years of austerity productions, it is a pleasure to take up a book which is so attractively printed and so well illustrated (with the exception of the frontispiece in colour). This attention to detail extends even to the dust-cover, which is of a very pleasing design.

T. I. W.

CONTACT LAMINATED PLASTICS

Low-Pressure Laminating of Plastics

By J. S. Hicks, assisted by R. J. Francis. (Reinhold Plastics Series.) Pp. ix+162. (New York: Reinhold Publishing Corporation, 1947.) 4.50 dollars.

THIS small book is to be welcomed as it is the first devoted entirely to the new techniques for moulding by laminating under comparatively low pressure. Starting with the almost inevitable definition of plastics, and disposing of all but the polyesters and related resins in little more than half a page, the author proceeds to describe the moulds used, the resins available, the procedures followed, the finishing of the objects made and the commercial aspects of these new methods. One excellent feature of the book is the large number of photographs illustrating both the stages in production of mouldings and the types of objects that result from them. Since manufacturers are frequently in doubt as to the type of goods for which low-pressure methods are suited, and it is presumably to manufacturers that the book is addressed, the book will serve a useful purpose in bringing home to industry the considerable scope offered by these new methods.

It is, therefore, all the more to be regretted that the book has been written so uncritically and in such a turgid manner. In almost every case where a number of alternative procedures are possible, they are enumerated without the outstanding merits or limitations of any one being considered. Plaster moulds have their advantages, but one could forgive a reader of Chapter 2, new to the subject, wondering why metal moulds are ever considered when plaster is available. Again, the lists of references are formidable and appear to contain all the important papers up to mid-1946, but they are so cluttered up with the titles of papers which were never worth the publishing that much of their value is dissipated.

Many subjects are treated in unexpected places, and the text abounds in irrelevant matter that makes reading difficult.

It is not surprising that the author, coming from Owens Corning Fiberglass Corporation, should devote most of his space to glass fibre cloth laminates, since this company has played a very important part in developing these techniques and is completely responsible for launching several of them; but the title suggests a wider field. Other materials are mentioned but are not given the importance they deserve. To-day more than half the supply of contact resins in the United States goes with paper to the making of continuous laminated sheet. This was not so in 1946, yet even at that time the process deserved a better fate than that of being treated under the heading of 'post forming' and being illustrated by such an inadequate and inaccurate diagram.

The book can be recommended to the people for whom it was written because it is the only one in the field and because there is a need for such a book. To these it will prove well worth its purchase price.

J. M. J. ESTEVEZ

DERMATOLOGY

Modern Trends in Dermatology

Edited by Dr. R. M. B. MacKenna. Pp. xiv+432. (London: Butterworth and Co. (Publishers), Ltd., 1948.) 42s. net.

THIS book might serve as an obituary notice to descriptive dermatology. The only chapter in which description of lesions is a feature is that by Dr. F. Parkes Weber on "Necrobioses, atrophies, scleroses, infiltrations and accumulations in the skin and subcutaneous tissue". It is not implied that the descriptive studies of the past, brought to perfection by Brocq and his followers, can in future be ignored. Without the ability properly to classify skin diseases from a knowledge of surface and cellular anatomy of lesions the practice of dermatology is impossible.

Classification of skin diseases is now becoming clearer and the general trend in dermatology is, as demonstrated in this book, towards biochemical, pathological and bacteriological investigation on a scale never before contemplated. Descriptive dermatology is not yet complete, however, and there might profitably have been included descriptions of such items, apparently unknown or unrecognized in Britain, as Gougerot's syndrome and Kœnen's tumours (found in some cases of epiloia). It is a pity that British dermatologists are not provided with any survey of world literature comparable with that available to the French in the admirable abstracts in *Les Annales de Dermatologie et de Syphiligraphie*.

Dr. MacKenna refers in his introduction to the fact that rare diseases receive much more study than do the common ones. His point is confirmed in the book, where the only common conditions fully discussed are the 'seborrhœic' eruptions (by Dr. H. W. Barber).

The widening scope of dermatological research and practice is indicated by chapters on "The Prevention of Cutaneous Diseases, excluding Industrial Maladies", by Prof. F. A. E. Crew; "The Rehabilitation of Patients Suffering from Cutaneous Disease", by Dr. F. F. Hellier; and "Psychological Aspects of Dermatology", by Dr. E. Wittkower. This last chapter is the best short account of the problem of neurodermatosis that I have read. Another outstanding chapter is that by Dr. L. Schwartz on "Occupational Dermatoses".

Dr. MacKenna is to be congratulated on his choice of collaborators, British and American, who have produced an excellent review of the modern trends and advances in dermatology. It is to be hoped that its success will merit further editions on the same lines as the need arises.

My only criticism is that there is no mention of that common skin disease, syphilis, which, in Britain, has become almost divorced from dermatology. Dermatology could be learnt from a study of syphilis and its differential diagnosis, and the dermatologist who does not know all about syphilis—and this is not rare—cannot be a master of his art.

JAMES MARSHALL

Electrons (+ and −), Protons, Photons, Neutrons, Mesotrons and Cosmic Rays

By Robert Andrews Millikan. Revised edition. Pp. x+642. (Chicago: University of Chicago Press; London: Cambridge University Press, 1947.) 30*s.* net.

THIS book is a revised and enlarged edition of Prof. Millikan's book "Electrons" which appeared in 1935, and was itself based on his celebrated work "The Electron" (1917), which in its day occupied a unique position in the literature of atomic physics. It is pleasing to note that the early chapters of the new edition still conform closely to the text of "The Electron", for they contain one of the few accurate accounts in English of the early history of the measurement of the atomic charge. The first fifteen chapters are essentially the same in the new edition as in the 1936 edition, except for emendations to the text, the most important of which is to the value of the atomic charge as obtained from observations of falling drops. This now appears as $e=4{\cdot}807\times10^{-10}$ E.S.U. It is also stated that the value $e=4{\cdot}803\times10^{-10}$ E.S.U. obtained from a comparison of X-ray diffraction from a ruled grating and a crystal lattice is the more precise.

The book is essentially a text on modern atomic physics with special emphasis on the discoveries of the various fundamental particles, and of cosmic rays. The new edition differs from its predecessors in giving more recent information in five additional and valuable chapters, which include a brief discussion of the utilization of nuclear energy and its international control.

The material is everywhere clearly and vividly presented with many illustrations, but the use of the first person singular throughout has rendered it difficult for the author always to give the impression of that scientific detachment which is desirable in an introductory text. L. G. H. HUXLEY

British Sources of Reference and Information

A Guide to Societies, Works of Reference and Libraries. Compiled under the direction of a Committee of ASLIB and edited by Theodore Besterman. (Published for the British Council.) Pp. vii+56. (London: Association of Special Libraries and Information Bureaux, 1947.) 6*s.*; to ASLIB members, 5*s.*

THIS useful desk tool could have been much more useful had its scope been limited and the defined objectives kept closely in mind. The accounts of the National Central Library, the copyright libraries and library organisations are admirable and adequate, though the references to the Association of Special Libraries and Information Bureaux itself and to the British Society for International Bibliography are already out of date. The sections covering the university libraries and the public libraries of Britain are also adequate although some expansion would have been welcome, particularly as Colonel Newcome's book and the "Yearbook of Learned Societies" are out of print. It is the 'select' list of special libraries that is most open to criticism. No attempt is made to indicate the basis of selection, but while it may be pardonable to omit St. Deiniol's Gladstone Memorial Library at Hawarden, it is difficult to know what to make of a list which omits, for example, the John Ryland's Library in Manchester or the libraries of the Manchester and of the Newcastle-on-Tyne Literary and Philosophical Societies and includes a number of bodies without a library at all. If the compilers in future editions discard the list of general works of reference, leaving this field, for example, to L. McColvin's "How to Find Out", and give the space thus saved to the sections indicated, the value of a promising little guide will be considerably enhanced.

R. BRIGHTMAN

Manual of Mathematics and Mechanics

By Prof. Guy Roger Clements and Prof. Levi Thomas Wilson. Second edition. Pp. ix+349. (New York and London: McGraw-Hill Book Co., Inc., 1947.) 3.25 dollars.

THIS manual, first published in 1937, has an unusual title, but, as the authors point out in their preface, the book "contains facts and formulas that are useful in courses of mathematics and mechanics in colleges and engineering schools, arranged and presented in a form that makes them readily available for *rapid work with minimum eye strain*". Here we have the key to the title, for the book is not a text-book in the generally accepted meaning of the term. This is the second edition, and consists of many useful tables and formulæ for reference, covering algebra, trigonometry, calculus, statics, kinetics of a particle, and the dynamics of rigid bodies. In the new edition, the section on spherical trigonometry has been expanded to include the needs of courses in navigation. New matter has also been added to meet the demand of the applications of mathematics to electrical engineering, including radio circuits, while formulæ and tables have been appended to meet special demands of courses in physics. The book is therefore very comprehensive, and excellently printed in clear type so that essential data may be readily selected. This applies especially to the many tables provided.

There is room for a book of this nature, provided it is properly used and does not displace the legitimate text-book. Such a reference book is really most useful to the student who has completed courses in mathematics and mechanics and thus has an intelligent fundamental knowledge of the principles upon which the various results here quoted are based. It would be profoundly dangerous to use a book of tables and formulæ as a text-book. With this reservation, the volume may be confidently recommended as a comprehensive and useful adjunct for mature students.

An Analysis of Volitional Life

By C. Lambek. Translated from the Danish by Agnete Kortsen. Pp. 104. (Copenhagen: Einar Munksgaard; London: Williams and Norgate, Ltd., 1947.) 8 Danish Cr.

ONE of the great difficulties of pure introspective psychology has always been the function of the will. The processes of motivation in the human being are complex and elusive if only consciousness is to be considered. Indeed, the exponents of dynamic psychology have suggested that this is due to the strength of the unconscious, and have propounded the well-known analogy of conscious volition being regarded as comparable to a baby on an elephant, the baby (consciousness) believing that it controls the behaviour, but the elephant (unconscious) in reality going where it wishes.

In this book a Danish psychologist attempts to define and dissect the nature of will. He disregards the possibility of feeling-tones (emotions) being the

cause of voluntary acts, and states that the intellectual, emotional and volitional processes are all interdependent and of equal importance. He believes that the spontaneous urgency of tendencies to develop is due to the presence of thought images and sense impressions, but that there are ancillary factors, stamps of attention and stamps of vitality, which result in variations of tension. Once motivation is started it is followed up by planning and execution, which indicate future changes and the order in which they are to take place.

This book unfortunately shows the superficial limits of introspective psychology and is not likely to interest the medical psychologist, but it may be of some interest to those studying pure classical psychology; although even those will find little new here. It is well produced, the paper and print are excellent, and the translation is well done.

CLIFFORD ALLEN

Sequential Analysis

By Prof. Abraham Wald. Pp. xii+212. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 24*s*. net.

SEQUENTIAL sampling methods were developed during the War and remained secret for some time. Accounts of the methods have since been published in statistical journals, and knowledge of them has been fairly widely diffused by lecture and discussion both in the United States and in Great Britain. Hitherto, however, there has been no systematic account in book form of the theory of the subject developed from first principles, and Prof. Wald's book is therefore a very welcome addition to statistical literature.

The book is in three sections. The first opens with the elements of the current theory of testing statistical hypotheses, and develops a general theory of sequential probability ratio tests. The second applies the general theory to special cases such as testing means and variances in sampling from normal variation. The third considers the problem of multivalued decisions and sequential estimation.

Prof. Wald writes as a mathematician, lucidly and carefully, with an obvious twinge when the necessities of a simple exposition force him to deviate from complete rigour. Practising statisticians will find it useful to study the book in combination with the bound set of reports (*SRG* 255) on applications of sequential analysis issued by the Columbia University Press (see *Nature*, **157**, 642; 1946).

M. G. KENDALL

Recent Advances in Sex and Reproductive Physiology

By Dr. J. M. Robson. Third edition. Pp. xii+336. (London: J. and A. Churchill, Ltd., 1947.) 21*s*.

IN the new edition of Dr. J. M. Robson's work, he has succeeded admirably in bringing the subject up to date, and the book has benefited by the inclusion of references to the more important papers which have appeared since the last edition. This is well seen in the account of the steroids, where it is shown that there is a relation between the chemical structure and the physiological action of all the hormones or hormone-like substances belonging to this class. The account of the probable factors in parturition is also especially interesting. Here the author points out that in various species the response of the uterus to oxytocin increases progressively during gestation and reaches a maximum at parturition, and the recent researches of Haterius and Ferguson are duly quoted. The factors concerned in ovulation are also discussed, and the evidence of a pathway from the hypothalamus in the brain to the anterior pituitary through the stalk is referred to. Chapter 10, on "Hormone Production and Excretion" under various conditions, and Chapter 13, dealing with "Clinical Applications", are particularly valuable.

F. H. A. MARSHALL

Severn Tide

By Brian Waters. Pp. vii + 183 + 16 plates. (London: J. M. Dent and Sons, Ltd., 1947.) 15*s*. net.

THE title of this book is perhaps slightly misleading. It is not a hydrographical treatise giving all the details of the propagation of the tide in the Severn, with ranges of tide, times of rising and falling, and so forth. Its main object is to relate the activities of the residents on the banks of the river to the flow and ebb of the tide. Nevertheless, the author gives many details regarding the famous Severn bore which are not to be found elsewhere; but these are scattered among many other things. It is as though the author takes the reader on a pilgrimage up and down the river, and in a leisurely way talks with all and sundry, exhibits interest in the details of their lives and occupations, their fishing and their farming, and so on, with intimate touches on how the tide in this river influences their lives.

It is a pleasant book, with much human interest, and it is one of those things which needed to be done, and has been well done. The age of craftsmanship is nearly gone, and the author has recorded many little details (for example, the particular shape of the bend in the handstaff of the lave net, and how such staffs are obtained) which are of interest to those interested in arts and crafts. This book will interest all who know the Severn, whether they be interested in the peculiar problems of navigating a boat with the bore, in fishing, in river lore, or in the intimate details of local life.

A. T. D.

Bibliography of the Technical Literature on Silk

By Dr. F. O. Howitt. Pp. xxiv+248. (London: Hutchinson's Scientific and Technical Publications, 1947.) 21*s*. net.

THE book is precisely described by its title. It is the result of a literature survey which Dr. Howitt undertook after his appointment as head of the Silk Section of the British Cotton Industry Research Association in 1936. At that time there was no systematic review of the widely scattered scientific and technological literature on silk, but Dr. Howitt has now made it possible to claim that the literature on silk is better documented than that relating to any other textile fibre. Starting with the cultivation of silk, he proceeds to discuss the properties of raw silk, sericin and fibroin. Then follow chapters on the preparation of nett silk yarns, degumming, weighting, dyeing, weaving, knitting and finishing. The book ends with a survey of testing methods and a brief reference to non-textile uses of silk. So thorough is Dr. Howitt's treatment of his subject—there are 528 references in the fifty-six pages devoted to the properties of fibroin—that reading would have been difficult if the information had not been so well co-ordinated. The author can be congratulated on his contribution to the newer scientific literature on textile materials and processes.

J. B. SPEAKMAN

HUMAN FACTORS IN INDUSTRY

CONFERENCE AT LEAMINGTON

IN the Assembly Rooms at Leamington Spa, on May 8, the British Association's Division for Social and International Relations of Science held a conference on "Human Factors in Industry". At the first session, under the chairmanship of Sir Henry Tizard, president of the Association, Prof. R. E. Lane, Dr. C. L. Cope, Mr. H. C. Weston and Dr. T. Bedford spoke on the improvement of physical environmental conditions. At the second, under the chairmanship of Sir George Schuster, there were contributions by Dr. R. F. Tredgold, Mr. D. Chapman and Dr. A. T. M. Wilson on problems of human relations, and Mr. Alec Rodger summed up.

Prof. Lane, of Manchester, introduced by Sir Henry Tizard as the first holder of the first British chair of industrial medicine, dealt chiefly with the influence of environmental conditions on health, and in doing so stressed the value of the medical man's part in studying and improving them. He emphasized particularly the role of the industrial medical officer as an apostle of preventive medicine. In his view, a firm's occupational health should be the concern of a team led by the management, and representatives of various interests within the firm. The medical man could often help management to decide on the conflicting claims of experts inside the organisation. Prof. Lane indicated that training facilities, capable of producing men suitable for the educative and advisory work he had outlined, are now available. What was needed next was a guarantee from industry that there would be employment for the best type of medical officer. If that guarantee were given, the men would be provided.

Dr. Cope, director of research into human problems for the National Coal Board, confined his attention to the coal industry. As Dr. P. Hugh-Jones, a stimulating participant in the general discussion, put it, he spoke of darkness, danger and dust. Human wastage from accident and disease is greater among miners than among any other section of the industrial community. Deaths on the job average 550 a year, and accidents causing more than three days absence number 180,000 a year. Certifications of permanent incapacity from pneumokoniosis total 4,000 annually. The corresponding figures for nystagmus and dermatitis are 1,800 and 1,600. In addition, of course, the industry is afflicted with a multitude of wage disputes.

Vast changes are needed to remedy present bad conditions, and a start is being made. Ventilation is on the whole good, and lighting is improving. The number and efficiency of cap-lamps is rising steadily, and fluorescent lighting is being installed experimentally not only in haulage ways but also at the coal face. Attempts are being made to determine the effects of improved lighting on the incidence of nystagmus and accidents, and to facilitate the investigation of accidents a new system of accident recording, developed by Mr. J. W. Whitfield of the Cambridge Psychological Laboratory, has been largely adopted. In the effort to combat pneumokoniosis, dust suppression by spraying with water or foam is being tried extensively, and Dr. T. H. Jenkins is collecting data on the efficiency of these procedures. Dr. Cope indicated that improvements in working conditions at the coal face would probably come slowly, because the cost of making them has constantly to be balanced against the cost of coal to the consumer. He added that he did not wish it to be assumed that he regarded these improvements as more important than improvements in human relations.

Mr. Weston and Dr. Bedford, both of the Industrial Health Research Board, summarized the findings of the Board's investigations in the fields of lighting, heating and ventilation. In the course of his talk, which was delivered in Stygian conditions not conducive to satisfactory note-taking, Mr. Weston displayed a number of slides depicting good and bad lighting. Dr. Bedford gave the following six rules for the arrangement of pleasant and invigorating working conditions: (1) A room should be as cool as is compatible with comfort. (2) There should be adequate air movement but no local draughts. (3) The air movement should be variable rather than uniform and monotonous, for the body is stimulated by ceaseless change in the environment. (4) The relative humidity of the air should not be above 70 per cent and should preferably be much below that figure. (5) The average temperature of the walls and other solid surroundings should not be appreciably lower than that of the air and should preferably be higher. The combination of cold walls and warm air often causes feelings of stuffiness. (6) The air at head-level should not be distinctly warmer than that near the floor, and the heads of the occupants should not be exposed to excessive radiant heat.

In the discussion at the end of the first session of the conference, stress was laid on the need for operational research in the coal and cotton industries; and on the need for greater co-operation between medical scientists, engineers and others, not only for the improvement of environmental conditions but also for the improvement of the design and layout of machinery. Although all the main speakers had explicitly referred to the importance of psychological factors in the study of environmental conditions, it was evident that many members of their audience thought they had not made enough of this point.

Opening the second session, Sir George Schuster, chairman of the Industrial Productivity Committee's Panel on Human Factors, said that our aim must be to make industrial employment the basis of a satisfying life. The main problem is to discover how scientific workers can influence the conduct of industry at the present time and in its present mood. At what points should the man of science intervene? What methods should he use? In answering these questions, we must realize that conditions vary from one industry to another and from one place to another; the introduction of joint consultation to a coal-mine throws up difficulties different from those encountered in its introduction to a cotton-mill.

Dr. Tredgold, of the Roffey Park Rehabilitation Centre, maintained that 'human relations' is merely a new label for an old subject, but that, in fact, we know very little about human relations in industry. Particularly, we have not sufficiently recognized the need for social skill in those we call leaders: in selecting them, we have assumed that technical qualifications are enough, and we have given them very little training. To some extent, training is now being provided for junior leaders, but training for management is still inadequate. It is important for leaders to realize that very often people do not do what they should because they do not see *why* they should. If we want people to act in a certain way, we should take pains to see that they appreciate our reasons, and we should seek to understand their

prejudices. In a passing comment on rehabilitation, Dr. Tredgold remarked that the aim at Roffey Park is not merely to encourage people to look after themselves, but also to encourage them to look after others.

Mr. Chapman, of the University of Liverpool, considered that the current tendency to exclude consideration of the pay-packet from discussions on incentives has gone too far. Financial incentives are undoubtedly important. At the present time, however, the proper use of them presents many difficulties; and we have yet to develop the social processes needed to secure the adoption, by management and workers, of modern payment systems. Suspicions based on their experience during periods of mass employment are still widespread among workers, many of whom doubt whether full employment will last. However, in the newer industries which make considerable use of semi-skilled and young workers, there is a more rational attitude than that commonly found in, for example, the cotton industry. Mr. Chapman remarked that in his view some of the unwillingness to produce additional effort was caused by the 'P.A.Y.E.' system of collection of income tax, which creates the impression that hard workers are penalized. He added that we must not overlook the fact that there is evidence that during the last thirty years national morale has declined considerably. Present culture patterns reflecting the decline include the popularity of football pools, self-medication, the building society movement and insurance-for-all.

Nation-wide exhortations have little or no effect; sometimes, Mr. Chapman said, they have a bad effect. The approach should be to the working group concerned, and the schemes proposed should not be elaborate. One firm has recently developed a simple piece-work scheme based on the advice of consultants who had said that output could be increased by a third. After persuading the local union organiser that the plan was not a capitalist plot, the firm tried it out in one small department. When the operatives in the department had accepted it, a team of people, including two workers, were asked to arrange for its extension to other departments. The scheme has so far been a great success. Elsewhere, a 'production drive' technique had been adopted. This was Saturnalian in character, for the trade unions had been persuaded to make substantial concessions for a fixed period. For example, young workers had been allowed to compete for prizes of up to 3 guineas. An increase in output of 75 per cent had been obtained by this method, and efficiency had become an important factor in prestige. A drawback of the scheme was its tendency to make mothers ask: "If Alice can get an extra pound this week, why not next?" Facile solutions, it must be recognized, have their dangers.

Dr. Wilson, of the Tavistock Institute of Human Relations, developed with emphasis Mr. Chapman's arguments about the importance of regarding the working group as a group. From birth onwards we are members of groups; our behaviour is greatly influenced by our membership of various groups; and our behaviour in one group is not the same as our behaviour in another group. The chief cause of low productivity often lies in bad group morale. We must therefore be ready to investigate factors affecting the morale of the group as a whole, and its constituent sub-groups, as well as factors affecting the morale of the individuals concerned. We cannot do this satisfactorily by conventional scientific procedures of observation and experiment. We must develop a close relationship with the group. This relationship must be more than a very friendly one; it must be therapeutic. In fact, only through a healing approach can diagnosis properly be effected.

If we pursue this aim by this method, what do we find? One of our discoveries will be that the workers in a group have spontaneous co-operative tendencies which are often denied expression. Another will be that there exists in industry (as outside it) an almost universal system of 'scapegoating'. This leads every group—management, line executives, technicians, office workers, supervisors, workers at the bench and on the shop floor—to find the causes of their own dissatisfactions in other groups. However, despite its tendency to blame other groups, every group has a 'need' for good relations with those others. For example, behind the envy which the shop worker feels for the clerk, there is often a real desire to work in a community in which hostility does not exist. Dr. Wilson concluded that, in fact, most groups have it in them to overcome their difficulties, and he pleaded for arrangements which would enable them to release their self-healing resources by free discussion and other means. This in turn led him to strong advocacy of the abandonment of autocratic practice and its replacement by honest co-operation.

In his summing-up, Mr. Alec Rodger, senior psychologist to the Admiralty, spoke critically of certain points made in the main contributions to the first session of the conference. He was in full agreement with most of Prof. Lane's remarks, but he disliked his suggestion that the industrial medical officer should become a kind of 'super'-adviser to management simply because he is a medical practitioner. If Prof. Lane could recruit doctors of the quality he wanted, he would, in fact, soon find them performing the duties he had planned for them; otherwise he would not, nor should he. Dr. Cope, Mr. Weston and Dr. Bedford had given convincing proof that in their particular fields much progress had been made, but it seemed to Mr. Rodger doubtful whether their findings are being utilized satisfactorily as the starting points for further researches. The American Hawthorne experiments had been used for this purpose: why could not ours? Mr. Rodger wanted to know whether, as a matter of routine, experiments on the influence of 'old' and 'new' environmental conditions were followed by investigations of the influence of what he called 'reinstated old' conditions. He thought they should be. In a comment on Dr. Wilson's address, with which he was in general sympathy, he challenged Dr. Wilson to explain why he and his colleagues are convinced that problems of human relations in industry cannot be studied by conventional scientific procedures.

Mr. Rodger urged, in conclusion, that we should recognize the present importance of short-term research in the industrial field; that we should readily participate in the co-ordination of our researches (by groups of recognized and accepted experts who would 'vet' research proposals and ask, about each, What problem is this meant to solve? How important is it that it *should* be solved? Is this the best way of solving it?); that with the aid of the statistician, who is indispensable in researches involving many variables, we should make more determined use of ordinary observational and experimental methods of inquiry; that we should learn to communicate our findings, in simple words and

pictures, to everybody concerned (from politicians and senior Civil servants to workers on the shop-floor); that we should take pains to let people know what our functions are; that we should constantly strive to acquire more appreciation of the problems of the managers we advise; and that, above all, we should investigate thoroughly the causes of managerial and shop-floor resistance to techniques intended to increase production. He suggested that the British Association should later stage a conference with a broader sweep, at which a series of short progress reports might be read on 'fitting the man to the job' and 'fitting the job to the man'. Under the first heading might come work on the improvement of methods of vocational guidance, personnel selection, and occupational training. Under the second might come the improvement of methods of work, design and layout of working equipment, and working conditions (both physical and psychological).

SCIENTIFIC RADIO

A SPECIAL feature of the programme of the Radio Section of the Institution of Electrical Engineers this session was the holding of a Convention on Scientific Radio during April 7 and 8. This Convention, which was organised by the Institution in co-operation with the British National Committee for Scientific Radio, afforded an opportunity for a preliminary survey of the British contribution to be presented to the forthcoming meeting of the Union Radio Scientifique Internationale (U.R.S.I.), which has already been announced in *Nature* of May 1, p. 695. The proceedings of the Convention were divided into four sessions corresponding in scope to the four commissions of the Union Radio Scientifique Internationale; and in each session four or five short papers were presented surveying progress in the past few years in various parts of the field of fundamental radio science. Ample opportunity was provided for speakers who wished to discuss the individual contributions, and abstracts of the papers and of the discussions will in due course be published in the *Journal of the Institution*.

Standards and Measurements

The first session, on "Standards and Measurements", was held under the chairmanship of Mr. P. Good, president of the Institution of Electrical Engineers; and the four papers presented on this occasion emanated from the National Physical Laboratory (Department of Scientific and Industrial Research). The chairman explained that this was perhaps to be expected, since it is one of the duties of the Laboratory to set up and maintain standards of reference for the electrical and radio measurements required by all users of the corresponding techniques. As was made quite clear by the individual speakers who followed, however, it was not intended to suggest that all progress made in recent years had been conducted within the Department of Scientific and Industrial Research; for it is well known that many substantial contributions during the war years were made by certain Government establishments and by industry.

Dr. L. Hartshorn, in a paper on "Radio Standards" presented jointly with Dr. L. Essen, first referred to the fact that, of the three standards recognized throughout the whole field of physical science, namely, length, mass and time, the last, if not already a radio standard, is very little short of it. For if once it is decided that the vibrations of the existing quartz-frequency standards are more regular than the rotation of the earth, then, for the period in question, the rotating earth is no longer to be regarded as the standard of either frequency or physical time. The paper pointed out the dependence of radio measurements on the existing electrical standards, and emphasized the need for distinguishing between definitive standards, derived standards, transfer standards and working standards. Reference was made to the changes which took place on January 1 last, when the ohm was defined by reference to the standards of length and time, with consequential changes in the numerical values of reactance and resistance of 0·05 per cent. Since inductance and capacitance standards can now be measured at radio frequencies with an accuracy of about 0·01 per cent, these changes are of decided significance in precision radio measurements. Frequency can be measured to a much higher order of accuracy, and an illustration was shown of relative measurements on three typical quartz standards, differing widely in design. These were found to agree with one another to within 2 or 3 parts in 10^8 over a period of several months.

In the following paper, Dr. T. I. Jones reviewed the techniques used in the measurement of current, voltage, impedance and attenuation at frequencies below about 300 Mc./s. Signal generators and receivers are calibrated in terms of voltage which, at a level of about 0·1 volt, can conveniently be measured by means of valve or crystal-detector voltmeters, and by a combination of a vacuum thermo-junction and resistors in series or parallel. Suitable voltage-dividers are available to extend the range upwards and downwards. The methods available for measuring impedance fall into two classes: those which use resonance circuits and which are used for measuring components, cables and the properties of dielectrics; and bridge networks, which are available up to frequencies of the order of 50 Mc./s. but which deteriorate in performance for frequencies above 10 Mc./s.

Mr. F. M. Colebrook described the changes in technique which have taken place in recent years in conducting radio measurements at frequencies above about 300 Mc./s.; and some discussion ensued on the possibility of reaching agreement among workers interested on the value of this boundary frequency, above which current and voltage measurement should give place to the determination of power. The general position with regard to measuring technique at the very high frequencies now in common use remains substantially as has been described in various papers published in the *Journal of the Institution of Electrical Engineers* during the past two years.

The subject of radio field-strength measurement is of direct interest in connexion with all applications of radio-wave technique, and Dr. R. L. Smith-Rose presented a survey of the main lines of development of this subject over the past ten years or so. At the present time suitable field-strength measuring equipments have been developed on an experimental basis for all radio frequencies between about 0·1 and 600 Mc./s.; but there is a need for further development of these and for an inter-comparison of the different types available on both a national and an international basis.

Propagation

Sir Edward Appleton, secretary of the Department of Scientific and Industrial Research, presided at the next session, at which five papers were presented dealing with some topical aspects of the subject of radio wave propagation. Dr. A. C. B. Lovell gave an interesting account of his recent investigations on meteors, conducted by the aid of radar techniques at wave-lengths of a few metres and less. When a meteor enters the earth's atmosphere, it burns away at a height of about 100 km. and creates a dense concentration of electrons which scatter energy from incident radio waves. On a wave-length of about 4 m., the number of echoes which have been detected by available radio equipment is very closely related to visible meteoric phenomena. As the wave-length is increased, however, the rate at which echoes are detected undergoes a striking change, and at wave-lengths greater than 8 m. several hundred echoes per hour are received, a number which bears no close relation to the visible observations. The sporadic ionization in the *E*-layer of the ionosphere is now considered to be mainly caused by the effect of meteors, particularly in temperate latitudes.

In 1934 it was discovered that radio waves traversing the ionosphere could interact with each other in such a way that the modulation of one was transferred to the other. This effect was explained at the time by supposing that the absorption of energy from one of the waves increases the temperature of the electrons in the ionosphere, with a consequential increase in their collision frequency with neutral molecules. As a result, the absorption of the other wave is increased; and since this absorption varies with the modulation of the first wave, this modulation will be transferred to the second wave. Experimental work on this phenomenon has recently been resumed at the Cavendish Laboratory at Cambridge; and Mr. J. A. Ratcliffe described the manner in which he and his colleagues have been observing the phase of the transferred modulation, and comparing it with the phase of the modulation received direct, as a ground wave, from the interacting station. From the results of such measurements, it is possible to determine the collision frequency of the electrons at a known height; and the experiments have given values around 5×10^5/sec. for a height of about 85 km.

The third paper at this session was presented by Dr. W. J. G. Beynon, who gave an account of recent investigations on the reflexion of radio waves from the ionosphere at oblique incidence. He pointed out that it has long become established practice to calculate the maximum usable frequency for any desired transmission path from normal-incidence ionospheric data with an accuracy which is satisfactory for most practical purposes. Experiments on the absorption of radio waves carried out in Great Britain have shown that there is a marked disagreement between the apparent absorption at oblique incidence and that predicted on theoretical grounds from the values measured at normal incidence. In a similar manner, estimates of oblique-incidence ionospheric absorption obtained from observations of signal strength over trans-Atlantic radio circuits disagree with the values expected from long-term normal-incidence measurements. This subject of the absorption of radio waves in the different regions of the ionosphere is being actively pursued at the present time under the auspices of the Radio Research Board of the Department of Scientific and Industrial Research.

The need for increased knowledge on the propagation of very long radio waves has recently come into prominence due to the development during the War of some novel and very accurate methods of defining the position of a radio receiver, by measurements made on the arriving waves. Work on this subject was in progress at the Cavendish Laboratory before the War; and Mr. R. N. Bracewell gave an account of the experiments, which have now been resumed, on frequencies of 16 and between 30 and 40 kc./s., corresponding to wave-lengths of about 19,000 and 9,000 m. respectively. The height of reflexion of these very long waves is about 80 km., with regular diurnal variations, which are symmetrical about noon, of some 18 km. in summer and 12 km. in winter. Such measurements are made by determining the phase path of the sky wave received at distances of a few hundred kilometres, using the ground wave, which varies little with respect to the transmitter, as the source of reference.

Dr. H. G. Booker presented a new way of visualizing the Sommerfeld theory of propagation over a flat and imperfectly reflecting earth. This theory arose because the ray theory involves the assumption that the Fresnel reflexion coefficient of the earth does not vary rapidly with angle of incidence, and this assumption is not satisfied for vertically polarized medium waves as used for broadcasting, arriving at the earth's surface at glancing incidence. The main object of the new presentation is to facilitate the solution of problems involving propagation near the surface of the earth partly over land and partly over sea, a condition which applies frequently in practice to radio transmission for communication and other purposes.

Radio Noise

At the third session, on "Radio Noise", the chair was taken by Sir Robert Watson-Watt, who is chairman of the British National Committee for Scientific Radio. In a paper entitled "A Survey of Recent Progress in the Study of Fluctuation Noise", Dr. D. K. C. MacDonald referred to the report made by the Union Radio Scientifique Internationale on this subject in 1946, and to the subsequent publication of the associated work primarily directed to war requirements, which was concerned broadly with noise at frequencies of 60, 600 and from 3,000 to 10,000 Mc./s. The main problems have been in the development of methods and instruments for noise measurements, of valves, circuits and crystal detectors to improve the ratio of signal to noise. It is well established that certain elements show increased noise at relatively low frequencies; and a study of this phenomenon, which includes 'flicker effect' in valves and 'current noise' in semi-conductors, is of considerable significance, for example, in the design of amplifiers for the study of physiological effects.

During the past few years, there has been a marked resumption of interest in 'atmospherics', a subject which had hitherto been rather neglected by radio physicists for some ten years. Two papers presented to the Convention served to direct attention to the investigations now in progress. In the first of these, Dr. T. W. Wormell and Mr. E. T. Pierce described some recent studies made at the Solar Physics Observatory, Cambridge, on the structure of the disturbances in the vertical electric field at the earth's surface resulting from lightning discharges.

In one type of investigation cathode-ray tube equipment and photographic recording technique are used to investigate the variation with time of the electric field produced by discharges not more than 50 km. distant. Concurrently, an investigation is being made of the detailed wave-form of the disturbance due to radiation from discharges at distances of many hundreds of kilometres. The results of such observations were discussed with the aid of photographic records and diagrams.

In the second paper, Dr. H. A. Thomas, of the National Physical Laboratory, described some of the results obtained from an analysis of observations of the strength of atmospherics as measured at some fourteen stations in various parts of the world. A large number of slides were shown to illustrate the general trend of these observations, which were made on five frequencies between 2·5 and 20 Mc./s., in which band the propagation of radio waves through the ionosphere is likely to play an important part in determining the general strength of atmospheric noise at any place. One of the important conclusions from this study, however, is that the characteristics of the atmospheric noise observed at any one location do not appear to be applicable over any large area; and this would tend to indicate that the sources of the noise being measured are local to the observer. Large differences between the ratio of day and night values are observed at different places; seasonal effects are marked, and also differ appreciably with location. Far more data on this subject are required, however, before any very definite conclusions can be drawn on such a complex subject.

The remaining two papers in this session dealt with recent investigations of the characteristics of galactic and solar radiation. Mr. J. S. Hey described how the emission of high-intensity radio waves from sunspot regions was first established by observations made with Army radar receivers in February 1942, during the transit of a large and active spot across the sun's disk. In the intervening years many workers have made observations of this phenomenon, particularly during the recent maximum of the sunspot cycle. The intensity of the radiations observed is particularly strong for a wave-length around 5 metres, and falls off very considerably as the wave-length is reduced below 1 m. Corresponding reception of this type of radio noise, as first noted by Jansky in 1932, has also been studied by recent workers; and in the discussion of this paper, Dr. J. L. Pawsey described some interesting observations, made in Australia, on galactic noise, from which it appears that some of the stars, or combinations thereof, radiate much more strongly than sunspots. This was followed up by Mr. M. Ryle's paper, describing experiments made on radiation emitted by the sun on wave-lengths of 1·7 and 3·8 m. The observations have been continued over a period of fifteen months, and it has been found that in the absence of sunspots the sun radiates with an intensity corresponding to a surface temperature of 10^6 °K. The radiation from sunspots is characterized by sudden increases of intensity which correspond to much higher temperatures.

Radio Physics

At the fourth session of the Convention, on "Radio Physics", the chair was taken by Prof. G. I. Finch, president of the Physical Society. The papers presented at this session demonstrated the manner in which some physicists are using the very high-frequency radio techniques, corresponding to wave-lengths of a few centimetres and less, to study various properties of solids, liquids and gases. Dr. B. Bleaney described the use of centimetre waves for studying absorption lines in the spectrum of gases due to heavy polar molecules. By making the radio frequency measurements to a high order of accuracy, the broadening of the lines due to collisions has been investigated at pressures up to six atmospheres. At low pressures (0·1–10 cm. mercury), the widths of the lines vary directly with the pressure; while at pressures above one atmosphere, the line breadth ceases to rise as rapidly as the pressure. Among the most interesting spectra studied in this manner are those of ammonia and water-vapour, the latter being of particular importance as a constituent of the atmosphere.

In their paper on "High-Frequency Absorption Phenomena in Liquids and Solids", Prof. Willis Jackson and Dr. J. A. Saxton directed attention to the significance of investigations on such materials as polythene, which is substantially non-polar, and liquid water, which exhibits purely polar characteristics. Such centimetre-wave measurements have served to illustrate more convincingly than previous work at longer wave-lengths the limitations of the original dipole theory of dielectric absorption formulated by Debye. With the reasonable prospects now in view of the extension of the range of these measurements to the millimetre wave-band and so towards the far infra-red portion of the spectrum, such investigations present interesting possibilities of leading to a fuller understanding of the properties of the liquid and solid states. In the meantime, the data already acquired on the absorption and scattering effects of water, ice and water vapour are of great value in connexion with the use of centimetre wave transmission through the atmosphere, and with the effect of fog, clouds, rain and snow on such transmission.

In the course of another paper in this session, Drs. R. Cooper and W. A. Prowse described experimental determinations of the minimum electric breakdown stress in air at frequencies corresponding to centimetre wave-lengths. It was found that radioactive irradiation of the spark gap improved the precision of the measurements without affecting the deductions drawn from the results. Spectrographic observations were made of the spark itself, and of the accompanying bright spot on the electrodes.

A paper entitled "Investigations of Magnetic Phenomena at Centimetre Wave-lengths" was presented by Dr. J. H. E. Griffiths, of the Clarendon Laboratory, Oxford, in which he stated that it is only recently that it has been possible to make measurements on the permeability of ferromagnetic materials in the centimetre wave region, and these have led to some interesting results. In addition to studying the permeability, which decreases rapidly with increase of frequency, the effect of a superimposed steady, transverse magnetic field has been investigated. It is then found that ferromagnetic metals exhibit a resonance phenomenon, in that the high-frequency loss in the metal becomes a maximum for a certain value of the steady magnetic field. A number of paramagnetic salts show a similar resonance absorption, and the interpretation of the results of such measurements is leading to a better understanding of the magnetic properties exhibited by various substances.

The last paper in the session, and also of the Convention, was presented by Mr. A. B. Pippard,

who described experiments on the high-frequency conductivity of metals at low temperatures. It is well known that the classical theory, supported by measurements at moderately high frequencies, indicates that the resistivity of a conductor as determined by the skin effect should be inversely proportional to the square root of the bulk conductivity. Experiments made at a frequency of 1,200 Mc./s. have shown, however, that while this is true at room temperature, the great increase in conductivity due to cooling pure metals to very low temperatures is not accompanied by a corresponding decrease of surface resistivity. The explanation of this effect is that the free paths of the conduction electrons at low temperatures may exceed the classical value of the skin depth by as much as a factor of 100 under the conditions of the experiments. Thus it is no longer permissible to assume the validity of Ohm's law, since only a small proportion of the relevant electrons contribute to the surface conductivity. It is clear that we have here a quantitative radio technique for exploring the free paths of electrons, and investigations were referred to in which the method is being applied to the study of the surface characteristics of pure metals.

In the course of the discussion, Dr. R. A. Smith very aptly referred to the interesting fact that physicists, who had so ably assisted the radio investigators in the development and exploitation of radar and communications during the War, have now taken back into their own research laboratories some of the problems exposed by the radio engineers. The development of the higher frequency radio techniques in the past few years has clearly provided powerful research tools for studying the general physical constitution of matter. R. L. SMITH-ROSE

PROBLEMS OF TIDAL BIOLOGY

IN a letter published in *Nature* in 1944 (**154**, 300) it was pointed out by Prof. T. A. Stephenson, of University College, Aberystwyth (in continuation of an argument initiated by Prof. F. E. Fritsch, *Nature*, **154**, 144; 1944), that future investigation of intertidal biology in Great Britain demanded: (*a*) further work on the British coasts between tide-marks; (*b*) further work on the continental shelf of the British region below tide-marks; and (*c*) an attempt to make a preliminary world statement, based on a carefully selected series of surveys made by the same workers.

Since 1944 progress has been made towards the realization of all these objectives, but the present article is concerned particularly with the third one. Prof. Stephenson has now undertaken to write a monograph on plant- and animal-life between tide-marks throughout the world, and the expedition described below was a step in that direction. The monograph is intended to supplement the well-known works of Ekman ("Tiergeographie des Meeres", 1935) and of Sverdrup, Johnson and Fleming ("The Oceans", 1942). These volumes both provide world-wide pictures of certain aspects of marine life, but neither devotes particular attention to the intertidal region; nor is there any general work which attempts to do this. In the task which he has undertaken, Prof. Stephenson will have behind him thirty years experience of ecological work between tide-marks carried out in Australia, South and East Africa, Mauritius and Great Britain, much of which is embodied in a series of admirable papers. The shores of North America have now been added to the regions studied by him. In much of this work, of a type which could not be conducted unaided, Prof. Stephenson has been assisted by collaborators, and throughout Mrs. Stephenson has acted as his technical assistant.

Between December 1946 and January 1948, Prof. and Mrs. Stephenson made a thirteen months visit to the United States and Canada to collect new material for their monograph. It has been recognized throughout that, while nobody can expect to visit all the coasts of the world in this connexion, there is a certain amount of uniformity between one coast and another within the same temperature limits. There is thus reason to expect that a judiciously chosen series of samples will provide a basis for a general statement which, if only a first approximation, will form a foundation for later work. It so happens that most of the samples needed to complete Prof. and Mrs. Stephenson's earlier experience are to be found in North America. On this ground their visit was supported either financially or by the provision of facilities, or both, by a number of institutions in Great Britain and America.

While the intertidal ecology of the North American coasts is much better known than that of South America, it has been investigated less than might be supposed. There is an extensive literature dealing with the systematics of intertidal plants and animals, and a very considerable amount which describes the biology of particular species. Contributions reviewing the shore ecology as a whole are much fewer, and where they exist, may deal primarily with animals (for example, Hewatt[1]) or with plants (for example, Doty[2]) and rarely cover wide areas, except in occasional works such as that of Ricketts and Calvin[3], and the paper by Doty already mentioned. There are vast stretches of the coast which remain almost unknown from an ecological point of view. The places visited during the present work were chosen, so far as possible, in areas where the general shore ecology has not been described. The summary which follows is derived from a privately printed report prepared for submission to the institutions which supported the work.

The time spent in America extended from January 1, 1947, to January 25, 1948. During this period a distance of some 15,000 miles was covered, mainly by motor-car, and shore-work was carried out first on the Atlantic coast—among the Florida Keys, at Marineland in North Florida, at Charleston in South Carolina and at Beaufort in North Carolina. After crossing the continent it was continued on the Pacific coast at Nanaimo in British Columbia, and afterwards at Pacific Grove and La Jolla in California. This schedule permitted a stay of approximately two months at each of the main centres.

The amount of information collected was considerable, and it will be some time before it can be worked up for detailed publication. Meanwhile the following note will indicate the nature of the results. The work falls roughly under three headings: (*a*) broad geographical aspects; (*b*) questions of vertical and horizontal distribution within small areas; and (*c*) the causes of the facts observed under (*a*) and (*b*).

The Florida Keys represent a tropical region with an abnormally scanty intertidal population; scanty, that is to say, in total bulk of organic material regarded as a crop, not in number of species repre-

sented. The latter is considerable. The environmental features with which this poverty is connected appear to be produced by a peculiarly shallow, very heavily sedimented sea, with a low concentration of nutrient salts, operating in a tropical region with a rather small tidal range, on a clinker-like substratum formed from dead coral. This situation will be described for the first time, and it is hoped that a comparison of so unusual a tropical area with more ordinary ones will yield information about the underlying reasons for the differences.

The coasts of northern Florida, together with those of North and South Carolina, present an entirely different picture. It is hoped to show that between Cape Hatteras and Cape Canaveral there lies a region inhabited by a warm-temperate tidal biota with distinctive features of its own. The coast here consists primarily of sand, mud and gravel, outcrops of material harder than peat being exceptional; but the lack of hard substrata is made up for, to some extent, by the existence of rough rocky breakwaters essentially similar to reefs of natural rock. Information has been obtained relating to the reaction of a warm-temperate population of seaweeds and animals to the presence of small areas of hard bottom lost among vast tracts of sand, and it is expected that this will prove to be useful material for a general discussion of the problems of intertidal life.

On the Pacific coast, the areas visited provide the following special features. At Nanaimo in British Columbia there flourishes a superb example of a rich, fully marine fauna, in a region of quiet creeks with reduced wave-action, in a low range of salinity (23–28 °/₀₀). It is remarkable in itself that so large a population of stenohaline animals such as starfish and anemones should flourish in water of such low salinity; but the district offers also, in the form of Brandon Island, a small island with a gradual, sunny, southward slope and a precipitous, shady, northern cliff, a perfect demonstration of the effect on plant and animal distribution of the contrast between these two combinations of conditions. Other reefs and islands in the district supplement what Brandon Island supplies, and also offer contrasts. Around the Monterey Peninsula and Point Lobos in California, on the other hand, there is found an example of a more southern version of a population not unlike that of Nanaimo, but exposed (on the more wave-beaten promontories) to maximal oceanic wave-action. In spite of the powerful wave-action, however, the very rugged and irregular nature of the coast provides so many degrees of exposure to, and shelter from, wave-action in small areas that the effect of these differences on a rich marine population in an area of normal salinity can be studied to advantage. Lastly, in the neighbourhood of La Jolla, near the boundary between Mexico and California, another very different picture is encountered. The wave action, while considerable and oceanic, is moderate compared with that of the Monterey region; and the shore biota is of a warm-temperate type, distinctly different ecologically from that of the more northern stations. The rock along the shore, moreover, provides a remarkable demonstration of the effect of different degrees of hardness on the species which can colonize it. The most prevalent rock is so soft that it has specific unusual effects on common organisms such as barnacles and encrusting Corallinaceæ; and these effects can be checked by comparison with local areas in which the rock is harder, in varying degrees, than the average, and which show clearly what happens on hard rock as compared with soft in the same district.

Throughout the work special attention has been paid to the zonation of plants and animals between tide-marks, and the relationship between zones and tide-levels will figure largely in the results. During their previous work in South Africa (see *Nature*, **143**, 503; 1939; and **156**, 27; 1945) Prof. and Mrs. Stephenson developed the idea that the shore zonation found there is based on a plan of universal application. They were able to test this idea later in Great Britain, Mauritius and East Africa, but during 1947–48 tested it much more widely on a variety of American shores. So far it has stood this examination very well, but there is much work to be done before the detailed application can be made.

The regional peculiarities of different parts of the world reveal themselves in many ways. This is shown particularly well by the distribution of limpets, which is one of the subjects covered in this work. While limpets of some kind are peculiarly characteristic of the intertidal regions of the world, the *genera to which they belong* show a markedly regional occurrence. Thus, in some areas the leading limpet genus is *Patella*; in others *Acmæa*; and on many of the warmer shores the pulmonate *Siphonaria*. An interesting point brought out by the present study is that the Carolina coasts visited are most exceptional in that, to all appearance, they have *no limpets at all* on open rock surfaces.

The prime object of the work here summarized was not the amassing of facts as such but their comparative study with the view of elucidating the underlying fundamental principles which are responsible for the surface appearances described. These principles cannot, however, be formulated until a full examination of the facts has been made. In the course of this expedition Prof. and Mrs. Stephenson have added greatly to their already unique experience in the study of shore ecology. It is most sincerely to be hoped that nothing will prevent, indeed that circumstances will conspire to further, the production of the monograph to the completion of which on the broadest possible basis their labours are directed.

C. M. YONGE

[1] Hewatt, W. G., *Amer. Midland Naturalist*, **18**, 161 (1937).
[2] Doty, M. S., *Ecology*, **27**, 315 (1946).
[3] Ricketts, E. F., and Calvin, J., "Between Pacific Tides" (Stanford Univ. Press and Oxford Univ. Press, 1939).

OBITUARIES

Prof. G. H. Hardy, F.R.S.

GODFREY HAROLD HARDY, who died at Cambridge on December 1, 1947, was the creator of the English school of mathematical analysis and had been for more than a quarter of a century the leader of pure mathematicians in Great Britain. He was born on February 7, 1877, the son of Isaac Hardy, who was bursar and art master at Cranleigh School. He went to Winchester and, in 1896, as a scholar to Trinity College, Cambridge. He was fourth wrangler in 1898 and was placed in the first division of the first class in Part II of the Mathematical Tripos in 1900. He was elected a fellow of Trinity in 1900 and (together with Jeans) gained a Smith's Prize in 1901.

At the turn of the century, pure mathematics in Britain was at a low ebb. Since the days of Newton,

mathematics had been regarded as ancillary to physics, and the achievements and prestige of Maxwell, Kelvin and Stokes had prolonged this attitude throughout the nineteenth century. There had been great pure mathematicians (such as Cayley), but they had worked in isolation and had been untouched by the movements in France and Germany.

In "A Mathematician's Apology" (1941), Hardy recounts his introduction to analysis—"My eyes were first opened by Prof. Love, who taught me for a few terms and gave me my first serious conception of analysis. But the great debt which I owe to him—he was, after all, primarily an applied mathematician—was his advice to read Jordan's famous 'Cours d'Analyse'; and I shall never forget the astonishment with which I read that remarkable work, the first inspiration for so many mathematicians of my generation, and learnt for the first time as I read it what mathematics really meant."

From 1900 until 1911 Hardy wrote many papers on the convergence of series and integrals and allied topics. Important as these researches are—they led to his election to the Royal Society in 1910—they are not his great work, and perhaps the most significant product of the early period was "A Course of Pure Mathematics". In this book Hardy expounded the basic ideas of analysis—limit, continuity, convergence—to the schoolboy of scholarship standard and the undergraduate. These ideas were so little appreciated that Hardy could then write (1908): "I have indeed in an examination asked a dozen candidates, including several future Senior Wranglers, to sum the series $1 + x + x^2 + \ldots$, and not received a single answer that was not practically worthless—and this from men quite capable of solving difficult problems connected with the curvature and torsion of twisted curves".

In revising the book for the seventh edition (1938), he could reflect that, if he were to rewrite it, it would no longer be necessary to write like "a missionary talking to cannibals".

About 1911 came the real crisis of Hardy's career when he began his long collaboration with J. E. Littlewood, a partnership without parallel in the history of mathematics. One problem after another was reduced by the powerful methods which they developed, and on some topics in analysis there now seems nothing more to be said. The main headings of the joint work of Hardy and Littlewood are convergence and summability of series, trigonometrical series, inequalities and the analytic theory of numbers.

Their most spectacular work was in the theory of numbers; there are problems which need only elementary arithmetic for their statement (for example, "Is every even number the sum of two prime numbers?"), but all the resources of analysis are required to make any impression on them. Some questions (including the one quoted) are still unanswered, but they are not now—as they were in 1910—unapproachable.

In 1914 began another collaboration, this time with a man whose gifts were much less like Hardy's own than are Littlewood's. A poor, self-taught Indian, Ramanujan, wrote to Hardy stating a number of formulæ that he had discovered. He was brought to England and before his death at the age of thirty-two in 1920 had become a fellow of Trinity and a fellow of the Royal Society. Hardy's association with Ramanujan was in some measure that of teacher and pupil; he had to teach Ramanujan much of the routine analysis which every Tripos candidate now knows, and this without impairing the native genius of the man. Their joint papers are few, but one of them contains a theorem so astonishing that one cannot help indicating it.

Denote by $p(n)$ the number of ways of expressing the positive integer n as the sum of integers. For example, 5 can be expressed as $1+1+1+1+1$ or $1+1+1+2$ or $1+2+2$ or $1+1+3$ or $2+3$ or $1+4$ or 5, and so $p(5) = 7$. It is plain that $p(n)$ increases rapidly with n; and $p(200) = 3972999029388$ (as was shown by a computation which took more than a month). Hardy and Ramanujan's achievement was to establish an explicit formula for $p(n)$, of which the leading term is

$$\frac{1}{2\pi\sqrt{2}}\frac{d}{dn}\frac{\exp\left\{\frac{2\pi}{\sqrt{6}}\sqrt{\left(n-\frac{1}{24}\right)}\right\}}{\sqrt{\left(n-\frac{1}{24}\right)}}.$$

Five terms of the formula give the correct value of $p(200)$.

Hardy was a lecturer at Trinity until 1919, when he became Savilian professor of geometry at Oxford; there he founded a flourishing school of research. For the year 1928–29 he went to Princeton, changing places with O. Veblen. He returned to Cambridge in 1931, succeeding E. W. Hobson as Sadleirian professor of pure mathematics; he held this chair until his retirement in 1942.

Hardy received degrees and honours from many universities and societies. He valued highly his honorary fellowship of New College, Oxford. During the last few weeks of his life he had pleasure in the award of the Royal Society's highest honour, the Copley Medal; he had already received a Royal Medal in 1920 and the Sylvester Medal in 1940.

In the course of his life, Hardy collaborated with many mathematicians besides Littlewood and Ramanujan; among others, with Titchmarsh, Ingham, Pólya, Wright, Rogosinski and M. Riesz. He had an exceptional gift for working with others, as he had for leading young men in their early days of research.

Hardy had one ruling passion—mathematics. Apart from that his main interest was in ball-games, of which he was a skilled player and an expert critic. An illustration of some of his interests and antipathies is given by this list of "six New-Year wishes" which he sent on a postcard to a friend (in the 1920's): (1) prove the Riemann hypothesis; (2) make 211 not out in the fourth innings of the last Test Match at the Oval; (3) find an argument for the non-existence of God which shall convince the general public; (4) be the first man at the top of Mount Everest; (5) be proclaimed the first president of the U.S.S.R. of Great Britain and Germany; (6) murder Mussolini.

It is fairly expected of a writer of a notice that he will, within the limitations imposed by language, attempt to portray his subject. How far would it be possible to describe Hardy, say to a mathematician of a new generation? His writings would attest both his power as a mathematician and his mastery of English prose. A picture might show his finely cut features and his physical grace. But no words can convey his liveliness and charm, which made a lasting impression on men even after one chance meeting, and which will remain fresh in the memory of those, mathematicians and others, among whom he lived.

Dr. Thomas Stephenson

THE death of the Rev. Dr. T. Stephenson, at Hindhead on April 15, removed yet another of that band of amateur botanists (others were Mr. H. W. Pugsley, Col. M. J. Godfery and Mr. P. M. Hall) who did so much during the past thirty years to advance our knowledge of British orchids. Born at Brackley in Northamptonshire in 1865, Dr. Stephenson was a minister of the Methodist Church for many years until his retirement in 1934. The continual change of residence involved in his calling brought him into many parts of Britain and enabled him to study his favourite group of plants in a great range of conditions and habitats. He concentrated especially on the marsh and spotted orchids (*Orchis*, section *Dactylorchis*) and on the helleborines (*Epipactis*), both extremely difficult and little-understood groups. In a series of more than twenty papers published during the period 1918–42, many of which were written in collaboration with his son, Prof. T. A. Stephenson, or with Col. M. J. Godfery, he contributed materially towards the elucidation and clarification of these two genera. His outstanding contribution was the recognition and description of *Orchis purpurella*, now known to be one of the most widespread marsh orchids of Britain.

Dr. Stephenson did not restrict his work on orchids to England but, with the assistance of grants from the Royal Society, made special trips to France, Spain and Algeria, where he was enabled to study not only the British species but also their western European allies.

In his later years, when resident in Torquay, he helped to edit the first part of the "Flora of Devon", which appeared in 1939, and to which he contributed the part on Orchidaceæ. His interest was, however, not confined to these plants, and he was preparing an account of the mosses for the second part of the "Flora" just prior to his death.

V. S. SUMMERHAYES

WE regret to announce the following deaths:

Dr. A. S. Corbet, of the Department of Entomology of the British Museum (Natural History), on May 16, aged fifty-one.

Sir Daniel Richmond, C.I.E., during 1927–32 chief conservator of forests, Madras, on May 1, aged sixty-nine.

Prof. Väinö Tanner, known for his geological studies of the Fennoscandian region, on April 26, aged sixty-seven.

NEWS and VIEWS

"Proposed Central Publication of Scientific Papers"

PROF. J. D. BERNAL writes: "In their letter published in *Nature* of May 15, the President and Secretary of Society for Freedom in Science put forward a number of reasons for rejecting the proposals for central distribution of scientific papers as set forward in my paper for the Royal Society Scientific Information Conference. The paper referred to, however, has not been published as it was intended for discussion in the first place and it is therefore impossible for most readers to judge how far it is open to the criticisms here given to it.

"Many of these do not apply to the proposals at all; others only to an interpretation of them which was certainly not the author's. Nearly all could be met by useful though inessential modification of the scheme. Thus there has been no proposal to abolish either journals, editors, or to curtail in any way their admirable functions.

"Although it would be possible to deal with these points in detail I feel that it would be preferable to leave discussion of them until the Conference where new statistical and technical material bearing on methods of publication and distribution will be available and where scientific societies will be fully represented. The scheme in question is only one of those before the Conference and is susceptible to modification and improvement. In any case the Conference can only indicate the direction in which changes in publication might be effected. The actual changes might be effected in an orderly way preceding each step by observation through operational research and voluntary experiment in a limited field. Any alterations would have to be negotiated with Societies and there is therefore little danger that the freedom of science will be interfered with."

Copies of Prof. Bernal's memorandum have been circulated to official delegates. In his memorandum Prof. Bernal states that: "More detailed descriptions of the steps which have led to the formulation of such a scheme are to be found in *Nature*, vol. 160, p. 649, 8 November, 1947, and the Report of Proceedings of the Twentieth Conference, 1945—Association of Special Libraries and Information Bureaux".

Dr. John Hutchinson, F.R.S.

THE retirement of Dr. John Hutchinson from the scientific staff of the Royal Botanic Gardens, Kew, on May 31, after forty-four years service, will be noted with interest by botanists in many parts of the world. Hutchinson's early life was spent in handling and working with living plants in various horticultural establishments, and he started his career at Kew on the Gardens' staff in 1904. He showed such marked capacity for systematic botanical work that after less than a year he was transferred to the Herbarium. Here he was engaged in systematic and taxonomic work under Dr. Otto Stapf, with whom he worked for many years in the closest harmony. He was 'Assistant' for India for six years, and 'Assistant' for tropical Africa for a similar period. It was then that his special interest in African botany developed, and he was placed in charge of the African section of the Herbarium in 1922. He was responsible for some of the difficult groups (Euphorbiaceæ, Moraceæ, etc.) in the "Flora of Tropical Africa", and later, in collaboration with the late Dr. J. M. Dalziel, for the whole of the "Flora of West Tropical Africa". Hutchinson's knowledge of African plants was enhanced by two extensive botanical expeditions in southern Africa between 1928 and 1930, and by a visit to West Africa in 1937. On the first of these expeditions he visited the greater part of the Union, including Namaqualand, and travelled with General Smuts in the Zoutpansberg. The second expedition was made at General Smuts'

express invitation; on this occasion they explored widely through Southern and Northern Rhodesia, Nyasaland and Tanganyika. The results of these journeys were described by Hutchinson in his attractive book, "A Botanist in Southern Africa" (Gawthorn, 1946).

In 1936 Hutchinson was appointed keeper of museums at Kew. He received the honorary degree of LL.D. from the University of St. Andrews in 1934, and in 1947 was made a fellow of the Royal Society in recognition of his services to science in the field of plant classification. His "Families of Flowering Plants" (2 vols.) has become a standard work. In the horticultural field his special interest for many years was the genus *Rhododendron* and later the genus *Sorbus*. He has received various horticultural honours, including the Victoria Medal of Honour of the Royal Horticultural Society. In his retirement Dr. Hutchinson hopes to complete a revision of Bentham and Hooker's "Genera Plantarum" and also some botanical works of a more popular kind. The good wishes of all his friends go with him.

American Awards for Work on Penicillin

THE United States Medal for Merit, the highest award made by the President of the United States to a civilian, has been presented to Sir Alexander Fleming and also to Sir Howard Florey for their work on penicillin. The citations accompanying the awards are as follow:

Sir Alexander Fleming, for exceptionally meritorious conduct in the performance of outstanding services to the United Nations during 1939–45. Sir Alexander has distinguished himself and benefited mankind through his fundamental researches and exceptional scientific contributions on the therapeutic use of penicillin, which were of major importance to the successful completion of the mission of the medical services in World War II. His personal and enthusiastic assistance to medical officers in the European Theatre of Operations greatly advanced the earlier application of the penicillin programme than would otherwise have been possible in that theatre, thereby contributing materially to the care of the sick and wounded soldiers and to the conservation of man-power. Penicillin was a significant factor in halving the death-rate from wounds of United States troops in World War II as compared with those of World War I. Thousands of soldiers are alive to-day, and other thousands have been spared crippling disabilities, because of Sir Alexander's monumental contributions on penicillin.

Sir Howard Florey, for exceptionally meritorious conduct in the performance of outstanding services to the United Nations during 1939–45. Sir Howard distinguished himself during this period through important contributions and fundamental researches in the development of penicillin. His foresight in conferring with United States scientists of the National Research Council in June 1941 greatly furthered the knowledge of this antibiotic agent and its potentialities, and made possible the large-scale production of penicillin, for the incalculable benefit of the sick and wounded. His vigorous leadership in the researches and utilization of this agent stimulated medical scientists to greater effort and greatly extended the field of usefulness of penicillin. His enthusiastic personal assistance to medical officers in the European Theatre of Operations was of utmost importance in providing penicillin therapy for sick and wounded troops in that theatre at an earlier date than would otherwise have been possible. The significant role of penicillin as a major factor in reducing deaths from wounds is apparent, for the rate was halved over the death-rate of World War I. Thousands of soldiers are now alive and other thousands have been spared crippling injuries because of Sir Howard's leadership in the development and utilization of this antibiotic agent.

Guthrie Lecture of the Physical Society

THE Guthrie Lecture of the Physical Society will be given this year by Sir George Thomson, his subject being "The Growth of Crystals". The Lecture will be given on June 4 at the Science Museum, London, S.W.7, at 5 p.m. During the First World War, Prof. Thomson made notable contributions to aerodynamics; later his attention was directed to the demonstration of the wave nature of the electron and the proof of de Broglie's Law. These experiments, now classical, earned him the Nobel Prize in 1937. After his appointment to the chair of physics at the Imperial College of Science and Technology, the work on electron diffraction in particular was continued and led naturally to an interest in surface layers and to the general question of crystal structure. During the Second World War, Sir George Thomson held a number of important Government posts and more recently was the British delegate to the Atomic Energy Commission of the United Nations Organisation.

Inter-Departmental Committee on Overseas Scientific Relations

THE Lord President of the Council, on the advice of the Advisory Council on Scientific Policy, has approved the setting-up of an Inter-departmental Committee on Overseas Scientific Relations to consider and advise on questions of United Kingdom Government policy on matters of overseas scientific relations. Sir Edward Appleton is chairman, and in addition to representatives of Government departments, the membership will include the foreign secretary of the Royal Society, representatives of the British Council and of the Conference of Research Associations, and two university men of science. The secretary of the Committee is Mr. H. L. Verry, head of the Overseas Liaison Division, Department of Scientific and Industrial Research, 142 Piccadilly, London, W.1.

Scientific and Industrial Research in Palestine

THE Government of Palestine Board for Scientific and Industrial Research, which is the successor of the Scientific Advisory Committee of the Palestine War Supply Board formed in 1942, has issued a "Report of Activities, April 1945–March 1948" accompanied by summaries of research and a list of publications of the Board (Jerusalem: P.O. Box 607 and the Hebrew University. Pp. 56. 150 mils.; 3s.). A list of standing advisory committees and sub-committees and their personnel is included, as well as of the projects carried out during 1946–48 and the institutions in which the research was located. Most of the investigations are being published in scientific periodicals, but full reports of all of them are available on request at the Office of the Board. The Sub-Committee for Citrus Products has compiled a card index of scientific literature on citrus products to serve as a reference work for further research. The index covers the period 1927–46 and will be

published in book form. The Sub-Committee for Water Research has dealt mainly with physico-chemical aspects of the problems, and a literature survey on the influence of ions on plants and soils has been published. Dr. M. Reiner, while studying methods of testing asphalt and bitumen used at the Road Research Laboratory in Britain, commenced investigations which led to the discovery of an important phenomenon in the deformation of asphalt, and visited England again in 1947 to follow up this discovery. A summary of his report on the rheological properties of bitumen and asphalt is included among the research summaries, as well as a joint note with A. Arnstein and M. Teinowitz on the loading test of reinforced concrete structures. Other research reports deal with bovine leptospirosis, the chemical composition of fodder plants in Palestine, chemical composition and nutritive value of foodstuffs produced in Palestine, citrus products, thermostable thromboplastin from human placenta, metabolic disturbance in diabetes, work hardening of polycrystalline metals, and several chemical investigations.

Royal Photographic Society's Annual Exhibition

THE Royal Photographic Society's ninety-third annual exhibition is to be held at the Society's House at 16 Princes Gate, London, S.W.7, during September and October this year. It will be in two parts, the first devoted to pictorial and colour photography and the second to scientific, technical, Nature and record photography. Lantern slides, colour transparencies and stereoscopic exhibits will be on view throughout the whole exhibition. The Scientific and Technical Group of the Society is very anxious to make the second part of the exhibition fully representative of the best work in all branches of modern applied photography. It may not be sufficiently widely known that the exhibition is open to all users of photography, and can assist them by giving them a standard against which to judge their own work. The Scientific Section of the exhibition is divided, for convenience, into seven classes: photomicrographs; radiographs (medical and industrial being judged separately); astronomical and meteorological; geological and metallurgical; survey (aerial and terrestrial); medical and surgical; other scientific photographs. Nature photography, record and technical photography (architectural, press, commercial and advertising) and kinematography are in separate sections. Scientific and technical films should be entered in the last section. Photographs produced in the course of scientific research are particularly welcomed.

Two awards are made annually by the Society in the Scientific Section, namely, the Hood Medal for meritorious performance in any branch of practical photography, and the Rodman Medal for outstanding work, preferably in photomicrography or radiography. The closing date for receiving entries is July 24.

American Section of the International Union of Crystallography

THE U.S. National Research Council has appointed a group of leading chemists, physicists and mineralogists to act as provisional executive committee of the American Section of the International Union of Crystallography, which will hold its first general assembly and congress at Harvard University during July 28–August 3. The Committee consists of Prof. L. O. Brockway, University of Michigan; Prof. M. J. Buerger, Massachusetts Institute of Technology; Prof. J. D. H. Donnay, Johns Hopkins University; Prof. I. Fankuchen, Polytechnic Institute of Brooklyn; Prof. C. Frondel, Harvard University; Dr. D. Harker, General Electric Co.; Dr. M. L. Huggins, Eastman Kodak Co.; Prof. A. L. Patterson (chairman), Bryn Mawr College; Prof. L. Pauling, California Institute of Technology; Prof. F. Seitz, Carnegie Institute of Technology; Prof. A. N. Winchell, American Cyanamid Co.; and Dr. R. W. G. Wyckoff, National Institute of Health. The Committee will recommend to the National Research Council a permanent constitution for the American Section of the Union, and will also advise the Council with regard to any matters which are of general concern to crystallographers in the United States. The British National Committee for Crystallography was announced in *Nature* of March 13, p. 390.

Education in Industry and Commerce

THE Minister of Education has recently announced that Lieutenant-General Sir Ronald Weeks has accepted the chairmanship of the newly established National Advisory Council for Education in Industry and Commerce. The Council has been set up to consider the national aspects of the policies of the ten regional councils and academic boards which have been constituted to develop and co-ordinate schemes for higher technological education in their respective regions. Sir Ronald was deputy chief of the Imperial General Staff from 1942 until 1945 and is now deputy chairman of Vickers, Ltd., and chairman of the English Steel Corporation, Ltd.

Conference on the Education of the Young Worker

A CONFERENCE on "The Education of the Young Worker" will be held at Manchester College, Oxford, during July 12–17, under the auspices of the Oxford University Department of Education, whose director is Mr. M. L. Jacks. The Conference aims at bringing together representatives of all the voluntary and statutory organisations, of central and local government departments, and others concerned in the education, employment and welfare of young people between the ages of fifteen and twenty, who are no longer receiving full-time education. It is hoped to produce a statement of policy applicable to the needs of these young people, setting out as clearly as possible the goals to be achieved in further education, whether in county college, industry or during leisure time. Suggestions will be made for practicable methods by which these goals can be achieved through the right co-ordination and administration of all available resources to form an integrated service, and some form of agreement will also be sought on the recruitment and training of all personnel who will be responsible for these young people. Well-known people, especially experienced in some aspect of this work, have been invited to speak at the Conference. The Conference itself will be divided into eight Commissions, namely: (1) county colleges; (2) leisure-time activities; (3) education in and through the job; (4) education for and in the Services; (5) recruitment and training of personnel; (6) differentiation in provision between the sexes; (7) differentiation between town and country; (8) administration and co-ordination. Further information can be obtained from the Director, University Department of Education, 15 Norham Gardens, Oxford.

Feeding Times of British Birds

THE Rev. John Lees has recently made observations into the winter feeding hours of robins, blackbirds and blue-tits (*British Birds*, **41**, No. 3; March 1948). These were made during the periods October 1945–March 1946 and October 1946–March 1947, and showed that there was a rough similarity between the feeding frequency of all three species. Each shows almost equal maxima in the forenoon and afternoon and a midday slackening of activity. Beyond this the differences are strongly marked. The robin has its maxima well separated, these being associated with the hours after sunrise and before sunset; the less active period over midday extends to about five hours. The blackbird has maxima close together, one and a half hours on each side of midday, the noon break being short and not pronounced. With the blue-tit the maxima are between those of the other two species and there is a well-defined break at midday.

British Bryological Society

THE members of the British Bryological Society assembled at Buxton during March 30–April 6 for the annual general meeting and week of field excursions. In spite of somewhat varied weather conditions, the members, under the leadership of Messrs. R. H. Hall and F. A. Sowter, visited Kinder Scout, Lathkill Dale, Dovedale and Monks Dale, and a considerable amount of field-work was accomplished. Two visits were made to Kinder Scout; on the first occasion the party proceeded to the edge of Kinder plateau via Grinds Brook, and on the second visit the ascent was made by Ashop Clough. The results of the field-work will be published later in the *Transactions* of the Society. The annual general meeting was held on April 2, with the president, Mr. A. Thompson, in the chair; the secretary, Mr. E. C. Wallace, reported a considerable increase in the number of new members. Dr. W. Watson (Taunton) and Mr. W. R. Sherrin (South London Botanical Institute) were unanimously elected honorary members in recognition of their long and valuable services to bryology and bryologists.

Matter-Radiation Cycle

REFERRING to his communication entitled "The Matter-Radiation Cycle in the Cosmos (and the Second 'Law'): the Sun's Equilibrium" in *Nature* of December 27, 1947, p. 906, Mr. Alfred Lauck Parson writes: "The expression used for the temperature which could be reached by inter-stellar matter in imagined finite groups of nebulæ should have been

$$T_2 = T_1 \times \sqrt[4]{\frac{A_1(1-F)}{A_2\left\{F + \frac{1}{A_2}(1-F)\right\}}}$$

and not $T_2 = T_1 \times \sqrt[4]{(1-F)}$, T_1, T_2 being the temperatures of the stars and of the interstellar matter, A_1, A_2 their superficial areas, and F the fraction of radiation escaping at the assumed radius of the group. The change does not affect the general conclusion."

Colonial Service Appointments

THE following appointments have been made in the Colonial Service: H. W. Hamlin, assistant conservator of forests, Tanganyika; H. S. H. Watson, assistant conservator of forests, Northern Rhodesia; J. R. Fletcher, inspector of mines, Malaya; A. J. MacNair, temporary agricultural (cocoa survey) officer, Gold Coast; J. Phipps, entomological biologist, Tanganyika; T. C. Stibbs, mining inspector, Lands and Mines Department, British Guiana; G. W. Lock (senior agricultural officer, Tanganyika), senior research officer, Tanganyika; A. E. S. McIntosh (senior agricultural officer, Federation of Malaya), deputy director of agriculture, Federation of Malaya; F. J. Pound (senior agricultural officer, Trinidad), deputy director of agriculture (crop husbandry), Trinidad; G. M. Roddan (deputy agricultural adviser, Colonial Office), deputy director of agriculture, Kenya; O. S. Swainson (senior agricultural officer, Zanzibar), director of agriculture, Zanzibar; S. G. Willimott (chemist, Department of Chemistry, Federation of Malaya and Singapore), chemist (soils), Federation of Malaya; H. A. Hay-Barclay (senior veterinary officer, Nigeria), regional assistant director of veterinary services, Nigeria; A. Fulton (senior veterinary officer, Gold Coast), director of veterinary services, Sierra Leone/Gambia; L. R. Hutson (chief veterinary officer, Leeward Islands), veterinary officer, Department of Science and Agriculture, Barbados; J. W. Macaulay (veterinary research officer, Northern Rhodesia), senior veterinary research officer, Northern Rhodesia; J. Morton (veterinary officer, Nigeria), regional assistant director of veterinary services, Nigeria; H. G. Stewart (veterinary officer, Uganda), senior veterinary officer, Uganda.

Announcements

PROF. PAUL FALLOT, professor of geology in the University of Nancy, has been elected a member of the Section of Mineralogy of the Paris Academy of Sciences, in succession to the late Léon Bertrand.

THE Stephen Paget Memorial Lecture of the Research Defence Society will be delivered by Prof. P. A. Buxton on the occasion of the annual general meeting of the Society, to be held at the Royal Society of Tropical Medicine, London, on June 8. Prof. Buxton's address will be on "Tsetse Flies and the Development of Africa", and it will be illustrated by a film in colour.

JOHN A. HARRISON, assistant education officer of Surrey County Council, has been appointed director of the Educational Foundation for Visual Aids. Mr. Harrison has had considerable experience of the use of visual aids to education both in the Services and in civilian teaching. During 1931–45 he used visual aids almost continuously in all types of education; in 1938, while holding a Carnegie research scholarship, he visited many American schools, giving particular attention to the use of visual aids.

AN appointment is to be made shortly to the Dewar Research Fellowship, tenable in the Davy Faraday Research Laboratory of the Royal Institution. The Fellowship, which is of the value of £1,000 a year, is open to persons of either sex, and is for a period of three years. The subject of research must be related to the chemical or physical sciences. Previous holders have been Prof. A. R. Ubbelohde, of the Queen's University, Belfast, and Dr. Kathleen Lonsdale, of University College, London. Applications must be made by letter to the General Secretary, Royal Institution, 21 Albemarle Street, London, W.1, before June 30.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Branched-Chain High Polymers

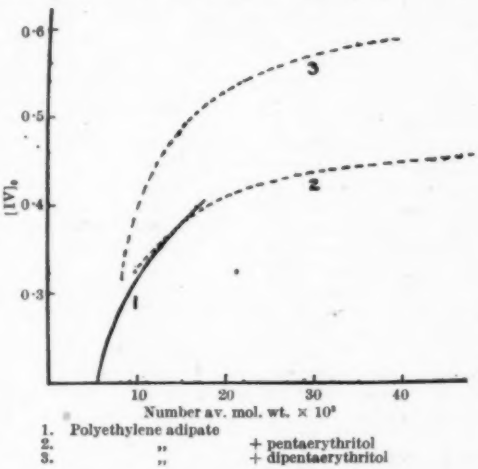
If two bifunctional molecules such as ethylene glycol and adipic acid are esterified in equal proportions, linear super-ester molecules are produced. In a similar way polyamides and polyurethanes may be produced, the chemistry of the process being such that only linear polymers are, in fact, formed. On the other hand, if one of the reactants contain three or more functional groups, for example, glycerol, then instead of linear molecules, branched molecules are first formed; but these branched products soon join up into three-dimensional networks which are insoluble and, therefore, not suitable for detailed investigation. Between these two extremes there must inevitably be produced molecules containing branched chains which, if the chains are not indefinitely long, should be soluble. Owing to the rapidity with which the network stage is reached, it has not hitherto been possible to isolate and characterize branched-chain molecules possessing long branches. Yet it is of great interest to know something of the thermodynamic and hydrodynamic behaviour of solutions of such molecules. The only branched molecule of which the structure has been determined is amylopectin. Here, however, it is not possible to vary the length of the branches while keeping the number fixed. It is, moreover, just the kind of variation that must be produced if the necessary information about branched-chain molecules is to be obtained. The present communication describes the attempts that have been made to synthesize, characterize and measure the properties of branched-chain super-ester molecules.

The principle of the method involves the copolymerization of a small amount of polyfunctional compound such as pentaerythritol, dipentaerythritol, trimethylol propane, with ethylene glycol and adipic acid. The polyfunctional compound is added to a polyethylene adipate of a high degree of polymerization; the polymer is then slightly depolymerized by heating at atmospheric pressure in nitrogen and then repolymerized, with the incorporation of the pentaerythritol, at 0·1 mm. of nitrogen. It proved possible to stop the reaction just short of the gel point, when polymers of a molecular weight much greater than that of the polyethylene adipate were obtained.

In order to characterize these polymers, it is necessary to measure the number average molecular weight by osmometry, and the number of chain ends or the number of points at which branching takes place. End-group determination proves to be most suitable. The method was tested with the parent polyethylene adipate, which was prepared by heating adipic acid with a threefold excess of glycol, no catalyst being present. The diglycol ester of adipic acid is first formed. This on further heating loses glycol, finally resulting in the formation of a super-ester with terminal hydroxyl groups.

A given weight of this ester was analysed for the total number of hydroxyl groups and the total number of molecules present measured by osmometry. It turned out there were on the average two hydroxyl groups per polymer molecule.

Using the same method with the supposedly branched polymers, it was found that those molecules containing pentaerythritol had four hydroxyl groups per molecule, and consequently must be cruciform in shape with the pentaerythritol nucleus at the centre. With dipentaerythritol, six hydroxyl groups per molecule are found, corresponding, therefore, to a molecule with six arms radiating from the dipentaerythritol nucleus as a star-shaped molecule. With trimethylol propane, $C_2H_5C(CH_2OH)_3$, the molecules contain six hydroxyl groups, implying, therefore, the incorporation of two trimethylol propane units before gelling sets in. Thus the structure of this polymer will be double *Y*-shaped, the two branches which it contains originating from two different points instead of the same point as with the pentaerythritol polymers. By varying the proportion of the polyfunctional alcohol, it is possible to prepare a series of molecules of the above-mentioned structures of different molecular weights from 10,000 up to about 50,000. This fact proves conclusively that these molecules contain long branches, because by this technique it is difficult to prepare linear super-esters with molecular weights exceeding 10,000.



1. Polyethylene adipate
2. ,, + pentaerythritol
3. ,, + dipentaerythritol

The intrinsic viscosity of solutions in chloroform are plotted as a function of molecular weight in the accompanying graph. With the linear molecules (curve 1) the intrinsic viscosity $[\eta]$ is not linearly proportional to molecular weight; the exponent in the equation $[\eta] = K(MW)^a$ is 0·9. With the branched-chain polymers, the intrinsic viscosity increases rapidly at first but tends to a maximum, the maxima being different for curves 2 and 3. The fact that the value of $[\eta]$ tends to become independent of molecular weight is in agreement with the Einstein theory of the viscosity of colloidal solutions, if it is assumed that the molecules are tending to a spherical shape in solution. The maximum value of the intrinsic viscosity of 0·6 is, however, much smaller than the Einstein value of 2·5. It will be observed that the linear polyethylene adipate and the cruciform adipate have similar intrinsic viscosities in the range 10,000–20,000 in molecular weight. Thus it would not be possible by measurements of intrinsic viscosity and number average molecular weight above to discriminate between molecules of such different structure. In fact, one general conclusion from these

experiments is that branching in a high-polymer molecule is unlikely to be easily detected even though an authentic linear polymer of the same number average molecular weight were available for comparison. In a similar way, the variation of viscosity with concentration of the branched-chain molecules as compared with linear molecules is in qualitative agreement with the theories already put forward, but the results are not nearly so clear cut as the theories would predict.

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Catalytic Poisons and Magnetic Susceptibility

The alkyl sulphides are powerful catalytic poisons for palladium, and the nature of the adsorption link is therefore of great interest. On chemical grounds, Maxted[1] has suggested a co-ordinate link from the sulphur atom to the metal. Here we record some preliminary measurements on the change in magnetic susceptibility of palladium due to adsorption of dimethyl sulphide. We conclude that electrons from the sulphur atom enter the *d* band of the metal (in an analogous way to the electrons from *dissolved* hydrogen atoms[2]).

A finely divided sample of palladium powder (prepared by reduction of palladium chloride in glycerine by hydrogen gas at 150° C.) was evacuated in an ampoule at 150° C., sealed off, and its susceptibility measured by the Sucksmith method[3]. The ampoule was then reattached to the vacuum apparatus and the palladium saturated with dimethyl sulphide gas at 20° C. The amount adsorbed was measured, the ampoule resealed and measured in the magnetic balance.

Column 2 of the accompanying table shows the change in susceptibility of the palladium powder expressed as a percentage change on the original value χ. Column 3 gives the percentage change in χ due to the effect of adsorption on the palladium alone; that is, it is the value in column 2 *minus* the calculated diamagnetic susceptibility of the adsorbed dimethyl sulphide.

$\frac{100\ a^*}{b}$	$100\ \frac{\Delta\chi}{\chi}$	$100\left(\frac{\Delta\chi}{\chi}\right)_{Pd}$	$100\left(\frac{\Delta\chi}{\chi}\right)_{calc.}$
27	10·1	8·0	13·5
23	7·9	6·0	11·5

* a moles dimethyl sulphide adsorbed on b gm. atoms palladium powder.

The effect of the dimethyl sulphide is outside the experimental error of 2 per cent on χ, and is of the right order to be expected if one electron from the dimethyl sulphide enters the *d*-band of the metal. Since dimethyl sulphide is an easily condensable gas, the adsorption will correspond to *at least* two monolayers; that is, a van der Waals layer on top of a chemisorbed layer. Only the chemisorbed layer will affect the susceptibility, and this will contain *up to* half the adsorbed quantity in column 1. At this stage we can do no more than assume that a chemisorbed molecule transfers an electron to a vacant surface *d* orbital, and thus the susceptibility of the surface palladium atoms is reduced to zero (there is 0·55 mole in the *d*-band per palladium atom[2]). This would then yield the calculated decrease in susceptibility shown in the last column.

It is not worth discussing the discrepancy between observed and calculated figures until experiments with clean surfaces have been made. The main point of contrast is that if the electrons entered the *s*-band of the metal, the susceptibility change would have been immeasurably small.

It is hoped to develop this experiment along more quantitative lines, since it offers an approach to an important aspect of adsorbed layers. These preliminary measurements were made in the Physics Department of the University of Bristol, and we are grateful to Drs. H. Heitler and L. C. Jackson for their help and advice.

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Feb. 2.

[1] Maxted, *J. Soc. Chem. Ind.* (in the press).
[2] Mott and Jones, "Theory of Metals and Alloys" (Oxford University Press, 1936).
[3] Sucksmith, *Phil. Mag.*, **8**, 158 (1929).

Synthetic Pentapeptides Related to Gramicidin-*S*

The polypeptide nature of several antibiotics is of considerable interest. As recent work in this field overlaps to some extent with our own, we wish to give a preliminary account of our studies on synthetic peptides related to gramicidin-*S*.

Synge[1] extended the limited data published by Russian workers[2–4], and suggested that gramicidin-*S* was the hydrochloride of a basic peptide with a stoichiometric minimum unit containing equimolecular proportions of the five amino-acids, *L*-ornithine, *L*-proline, *L*-valine, *L*-leucine and the unnatural *D*-phenylalanine. Each stoichiometric unit contained one free amino group but no free carboxyl groups. The free amino group was later identified[5] as the δ-amino group of ornithine, and gramicidin-*S* was formulated as a cyclic peptide of five amino-acids linked through their α-amino and carboxyl groups. Degradative studies involving the technique of partition chromatography furnished strong evidence for the structure [α-(valyl-ornithyl-leucyl-phenylalanyl-prolyl-)]$_n$ [6]. On the basis of the physical information so far available, gramicidin-*S* is best formulated as a cyclopentapeptide, or as a cyclodecapeptide where the above unit occurs twice in a closed peptide chain.

In the hope that some light might be thrown on the origin of the striking antibiotic action of this peptide, we decided to carry out parallel syntheses so as to obtain two pentapeptides with phenylalanine present in both its optically active forms. Numerous alternative routes to such a pentapeptide might be envisaged. After several different combinations had been tried, it was decided that for ease of handling, which was a dominant consideration, synthesis of a tripeptide from leucine, phenylalanine and proline, and the coupling of this tripeptide with a dipeptide from valine and ornithine, would have a reasonable chance of success. For all syntheses carbobenzoxy derivatives were employed according to Bergmann's

general procedure, and coupling was effected in each case through the acid azide.

Cbzo-L-phenylalanine hydrazide was converted to the azide, coupled with *L*-proline ethyl ester, and the carbobenzoxy group removed by catalytic reduction. The dipeptide ester with *Cbzo-L*-leucine azide gave *Cbzo-L*-leucyl-*L*-phenylalanyl-*L*-proline ethyl ester. The acylated tripeptide ester could not be crystallized, but analysed satisfactorily (found: C, 67·2; H, 7·3; N, 8·18; theory: C, 67·1; H, 7·3; N, 7·84 per cent). It was used for coupling with the appropriate dipeptide without further purification.

For the synthesis of the isomeric tripeptide a modified procedure was used which gave crystalline intermediates. *Cbzo-L*-leucine azide coupled with *D*-phenylalanine methyl ester to give *Cbzo-L*-leucyl-*D*-phenylalanine methyl ester, m.p. 110°. The hydrazide (m.p. 170°) from this ester gave an azide which was condensed with *L*-proline methyl ester; the resulting acyltripeptide ester was purified as the hydrochloride after removal of the carbobenzoxy group. The tripeptide methyl ester hydrochloride $[\alpha]_D^{20} = -38{\cdot}9°$ [anhydrous methanol, $C = 2{\cdot}0$] melted at 240°.

The two optically isomeric tripeptide hydrochlorides were tested *in vitro* against *Staphylococcus aureus*, *Streptococcus hæmolyticus* and *Escherichia coli*. Both peptides inhibited growth at a concentration of 1–2 mgm./ml., but were inactive at lower concentrations.

For preliminary experiments on open-chain pentapeptides we used the readily obtainable *DL*-ornithine rather than the rarer *L*-ornithine, as we did not consider that use of an optical mixture of *L*-valyl-*L*-ornithine and *L*-valyl-*D*-ornithine would affect the validity of our conclusions. *Cbzo-L*-valyl-δ-*Cbzo-DL*-ornithine methyl ester was prepared by the azide method and crystallized readily, m.p. 150°. This was converted through the hydrazide to the azide, and coupled with both the tripeptide esters already described. Both the dicarbobenzoxypentapeptide esters were difficult to handle; they set to stiff gels when attempts were made at recrystallization. After repeated precipitation of one gel, a product, m.p. 128–132°, was obtained which analysed satisfactorily for *Cbzo-L*-valyl-δ-*Cbzo-DL*-ornithyl-*L*-leucyl-*L*-phenylalanyl-*L* proline ethyl ester (found: C, 65·0; H, 7·4; N, 9·85; theory: C, 65·2; H, 7·2; N, 9·5 per cent). After five further 'crystallizations' from aqueous methanol, the small quantity of material remaining melted at 164° and again analysed satisfactorily.

The second, isomeric acylated pentapeptide ester melted at 198–200°, after purification by the same means, and analyses were satisfactory for *Cbzo-L*-valyl-δ-*Cbzo-DL*-ornithyl-*L*-leucyl-*D*-phenylalanyl-*L*-proline methyl ester (found: C, 64·5; H, 7·1; N, 10·0; theory: C, 64·8; H, 7·1; N, 9·7 per cent). As a final check on the identity of the two peptides, these were hydrolysed and the hydrolysates subjected to chromatographic analysis on paper by the usual technique[7]. The presence of the required five amino-acids was demonstrated by comparison with an artificial mixture.

The above work was essentially of an exploratory nature and was carried out on the smallest scale consistent with the requirements of the biological tests. We are now repeating the synthesis of the *LLLDL*-pentapeptide on a larger scale using *L*-ornithine so as to eliminate any doubts about the optical purity of the final product.

No significant difference in antibacterial action was apparent between 'natural' and 'unnatural' isomers at either the tripeptide or the pentapeptide stage. These results support the view already expressed[8] that antibiotics containing *D*-amino-acids are active, not because they have this character in common, but rather in virtue of their specific structures, of which the *D*-amino-acids must be regarded as an integral part.

Crowfoot (private communication) has expressed the opinion from a study of models that *D*-configuration of some of the constituent amino-acids in a peptide such as gramicidin-*S* would facilitate cyclization. It is thus reasonable to postulate that the activity of this peptide is a function of its cyclic nature. When larger supplies of open-chain pentapeptide become available, we hope to study the effect of polymerization and, if possible, of cyclization, on antibacterial action. A full account of this work will be published elsewhere.

We are indebted to Dr. A. T. Fuller for carrying out the biological tests.

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Reversion: a New Procedure in Absorptiometry

Many metals form coloured complexes with dithizone, and the successful use of this reagent for estimating one of them in a mixture demands a careful selection of organic solvent, a rigorous control of *p*H and other variables such as duration of shaking, nature and amount of neutral salts present, the concentration of excess dithizone, and the concentration of 'masking' reagents capable of competitive complex formation with interfering metals[1]. The coloured metal complexes (yellow, red, violet, etc.) modify the colour of the green solution containing excess dithizone giving a 'mixed-colour' extract, and by absorptiometric measurements the proportion of metal complex can be estimated with reference to calibration curves obtained by treating known amounts of metal by the standardized procedure. Such curves are commonly valid only for one initial concentration of dithizone, and error may be introduced in view of the well-known impermanence of this reagent. The theoretically obvious solution for such systems with two coloured components is to measure the transmittency at two appropriate wave-lengths; but this involves a burdensome amount of preliminary work for, in effect, a family of calibration curves must be constructed to cover all possible variations in reagent concentration and in the amount of metal taken for analysis[1].

In a systematic study of the estimation with dithizone of traces of mercury in biological

materials[3], we have shown that in the absence of suitable masking reagents mercury cannot be extracted quantitatively, even under optimum conditions, without co-extraction of more or less copper. Both theoretically and practically it is to be anticipated that this interference by copper (which is returned as mercury) will increase as the concentration ratio copper/mercury in the analysis sample increases. A similar situation will be encountered in other metal dithizone systems should the prescribed conditions of extraction be inadvertently departed from or the masking agent prove inadequate to the demands made upon it. In these circumstances the 'mixed-colour' extract will contain, besides excess dithizone and the metal complex being estimated, varying amounts of one or more unwanted metal complexes. No provision has been made for this contingency in any of the procedures described hitherto, and we have therefore developed a new approach.

If E_m is the optical density of a mixed-colour extract measured in a cell of length l, containing concentrations C_c of metal-dithizonate of formula MDz_n, C_d of excess dithizone, and C_i of other coloured impurities (foreign metals co-extracted as dithizonates, coloured impurities from the decomposition of reagent or from biological digests, etc.) of extinction coefficients ε_c, ε_d and ε_i respectively, then

$$E_m = l\,(C_c\varepsilon_c + C_d\varepsilon_d + \Sigma C_i\varepsilon_i).$$

If now the organic extract is shaken with an aqueous solution of some *specific* reagent which will decompose only the desired metal complex, returning the ions M^{n+} to the aqueous phase and liberating nC_c equivalents of dithizone in the organic layer, the optical density (at the same wave-length) will change to a value given by

$$E_r = l\,(nC_c\varepsilon_d + C_d\varepsilon_d + \Sigma C_i\varepsilon_i).$$

This process we term 'reversion'. The change in optical density, the reversion value, given by

$$R = E_r - E_m = l\,(n\varepsilon_d - \varepsilon_c)\,C_c,$$

is seen to be a linear function of the concentration of metal being estimated, and is independent of the concentration of dithizone taken.

Using a Hilger 'Spekker' absorptiometer with an Ilford Orange Filter No. 607, our reversion curve for mercury is linear over the range 0–2·4 p.p.m. A change in optical density of 0·1 corresponds to 0·33 p.p.m. of mercury, a sensitivity materially greater than that of the best contemporary methods[4]. Since $\varepsilon_d \gg \varepsilon_c$ at the wave-length chosen, all measurements involve essentially estimates of the same species (dithizone), and the same lamp-filter combination is used when determining both E_m and E_r. Indeed, if the concentration axis is graduated in units of gram-equivalents, a single calibration curve can be used, with no serious loss of accuracy, for the estimation of such varied metals as silver, lead, mercury and bismuth[5].

The major advantages of reversion procedure are: (1) standard solutions of dithizone are not required and changes in strength on keeping are unimportant; (ii) errors due to metals or other coloured materials co-extracted (term $\Sigma C_i\varepsilon_i$ above) are eliminated; and (iii) when estimating metals such as lead and cadmium where excess dithizone passes into the aqueous layer to an extent dependent upon the alkalinity of this medium, slight variations in the *p*H of extraction can introduce no error. The general principle of reversion is equally applicable to other suitable systems; for example, metals and oxine, or *o*-nitrosophenol, etc., or to measurements on mixtures absorbing in the ultra-violet or infra-red.

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Gases Liberated from Explosions Initiated by Impact

True detonation in high explosives normally gives as the major products gases such as carbon dioxide and monoxide, water, nitrogen and hydrogen[1,2], the relative quantities obtained being in general accordance with calculations based on equilibrium considerations. The thermal decomposition of explosives, on the other hand, gives more complicated products such as nitrogen oxides, aldehydes and complex condensation products, which may undergo further secondary reactions[3,4]. It was of interest to see whether the products from impact-initiated explosions would approximate more closely to those of detonation or thermal decomposition. Results with the two nitric esters, nitroglycerin and pentaerythritol tetranitrate, and the nitroamine, *cyclo*-trimethylenetrinitramine, reveal an intermediate behaviour. The figures are given in the accompanying table. The impacts were carried out in a vacuum apparatus[5]. For comparison, some figures for the explosive decomposition of nitroglycerin and pentaerythritol tetranitrate are quoted.

Composition of gases (per cent)*

	NO_2	NO	N_2O	N_2	CO_2	CO	H_2	O_2
Nitroglycerin								
Detonation[4]	—	—	—	32·0	63·1	—	—	4·9
Impact	—	29·7	2·3	11·7	28·8	22·5	5·0	—
Decomposition (180° C.)	—	50·3	1·0	2·1	17·2	28·9	0·5	—
Pentaerythritol tetranitrate								
Detonation[2]	—	5·3	—	22·8	37·0	26·7	6·8	1·4
Impact	—	24·3	5·3	9·4	19·1	35·4	6·5	—
Decomposition (210° C.)	12·0	47·6	9·5	1·6	6·3	21·0	2·0	—
cyclo-Trimethylene-trinitramine								
Impact	—	—†	11·3	43·3	18·8	21·3	5·3	—
Decomposition (267° C.)	—	22·5	22·8	31·0	13·2	8·7	1·8	—

* The water content was not determined. Considerable quantities of formaldehyde were noted in impact and decomposition experiments with *cyclo*-trimethylenetrinitramine and pentaerythritol tetranitrate.
† On some occasions a little nitric oxide was formed.

The results are consistent with the view that the decomposition under impact conditions occurs by a very similar mechanism to that operative in thermal decomposition, the secondary reactions of aldehyde oxidation proceeding to a further extent probably on account of the higher temperatures. The results are in harmony with the hypothesis of a thermal origin of impact-initiated explosions and with the slow initial burning velocities observed with the rotating-drum camera[7].

Our thanks are due to Mr. L. Phillips for analysing the gases from the thermal decomposition of nitroglycerin. This communication is published by permission of the Chief Scientist, Ministry of Supply.

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'Semaphore' Numerals

Enough is now known, as the Royal Society discussion on the subject on March 4 made clear [see *Nature*, May 8, p. 712], about the logical, physical and mechanical principles, and of the engineering, to make the existence of a number of high-speed digital computing machines a matter of time, and of comparatively short time, only. We can, in fact, do arithmetic at very high speed.

But the speed of any composite process is governed mainly by the speed of its *slowest* component. At present, 'input' and 'output' cannot take place at speeds in any way comparable with the attainable speed of computation. The machine should be able to do *all three* of the 'three R's' at comparable speeds—it must learn to Read and to wRite, and to do these quickly, as well as to do aRithmetic! Reading is the most important, for it should occur at a rate per digit comparable with an 'addition time'; but 'output' will not slow down the process if recording a result takes no longer than the chain of arithmetical operations which produces it.

Towards the end of the recent discussion, Mr. Wilkinson remarked that he had given some thought to the processes by which the human eye recognizes the numerals as printed or written, and seemed to imply that present forms would prove difficult for the low-grade intelligence of the robot to recognize. The alternative is, presumably, to introduce a new, simple and systematic set of numerals, simple enough for the robot but usable also by the human, so that mathematical tables might be printed in a form universally available, needing *no further coding* for the robot. We present here a possibility in this direction. While it would be unwarrantable optimism to presume that it is the last word, it is upon some such lines that progress depends, and a concrete suggestion may stimulate thought and discussion which vague generalities would not.

Working in the binary scale would be too cumbersome; working in some power of 2, say, 8 or 16, would not be too remote from the decimal scale—but it would entail the re-learning of arithmetic, 'multiplication tables and all that'. Indeed, a proposal to abandon the decimal system would be too revolutionary to stand any chance of general acceptance. But, fortunately, $10 - 1 = 3^2$, so that a dual use of a trinity of symbols will suffice. Such a possibility is presented by the three positions of a semaphore, upright, or inclined to left or right. The combination of upward-pointing and downward-pointing triads gives us the nine digits. A scheme, easy to write, easy to read—and *very* easy to remember—is presented in Fig. 1.

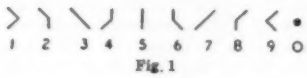

Fig. 1

Fig. 2

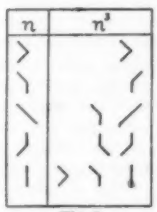

Fig. 3

The provision of a zero can be met by a central dot (a mere blank is not satisfactory). In writing, the comma can (as it now does in many countries) serve as a decimal point, and a lower point could—if desired—be used to indicate multiplication, but these would not be relevant to 'reading' by the robot.

The machine 'scanning' of the new numerals could be horizontally, for serial operation. Two 'eyes' are essential, but a third central one is desirable, to provide a time-scale and to sense the zeros.

The method is indicated by the dotted lines in Fig. 2. The three eyes will scan the lines *uu'*, *cc'*, and *ll'*, and the impulses due to crossing the lines or the dot will be interpreted by circuits in the machine so that the number read is fed into the appropriate register.

If this, or some similar, suggestion is accepted, it remains to fix an agreed standard size and spacing, and to use these numerals in printing all new mathematical tables. Re-coding of existing tables could also be undertaken. Some idea of appearance is given in Fig. 3, representing the beginning of a table of cubes.

Visual users of mathematical tables could rapidly master (and indeed use) the new code, and the problem of making robots wRite would be in no way more difficult.

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Angular Distribution of Radioactive Disintegration Products

The thermodynamics of the orientation of nuclei by strong magnetic fields at very low temperatures was worked out by Simon[1] in 1939. He found that with fields of 100,000 gauss and temperatures of 0·01° K., that is, under conditions which can be realized experimentally, the entropy of nuclear spin systems should be decreased by about 20–30 per cent, and would remain, of course, at this reduced value after adiabatic demagnetization. This would be sufficient to influence properties which depend on nuclear orientation, and the first experiments he contemplated were on the angular distribution of radioactive disintegration products originating from a partially oriented nuclear spin system. Prepara-

tions for these experiments, which were interrupted by the War, are now going ahead at the Clarendon Laboratory. It should be added that in the meantime experiments on nuclear induction have shown that the 'reaction velocity'—at least in some nuclear spin systems—is still very high even at temperatures as low as 1° K. [2].

In the present note, theoretical calculations have been made of the nature and magnitude of the effects to be expected. These are based on the state of the oriented system before the adiabatic demagnetization, as this is easier to realize in experiment. In making these calculations, the use of any particular 'models' of the process of disintegration has been avoided so far as possible, since it is possible to go a long way by applying some of the more elementary results of the theory of representations of the group of rotations to eigenstates of angular momentum.

The results so far obtained are as follows. Let $F(\theta)$ denote the angular distribution of the emitted particles (intensity in direction of emission θ, θ being the angle between the direction of emission and the direction of the orienting magnetic field). Then for a nucleus of initial spin J,

$$F_J(\theta) = \sum_M c_0^M \cosh M\beta + \sum_p \{\sum_M c_p^M \cosh M\beta\}. \cos^{2p}\theta, \quad (1)$$

where p is a positive integer $\leqslant J$; M is $-J, -J+1, \ldots, +J$; β is $\mu H/kTJ$; μ is magnetic moment of initial nucleus; H is magnetic field; T is absolute temperature; k is Boltzmann's constant; c_0^M, c_p^M are constants independent of H, T, θ, but otherwise dependent on the particular transition considered;

$$\sum_M c_p^M = 0, \text{ for all values of } p > 0.$$

This form of the function $F(\theta)$ holds irrespective of the nature and angular momenta of the particles emitted, and of whether they are emitted singly or together with other particles (as, for example, in beta emission). The term particle here includes photons. The constants c_0^M, c_p^M are undetermined by the general method used in establishing this formula.

A particular result is that for $J = 1/2$ there can be no directional effects.

If $\mu H/kT \ll 1$, a sufficiently accurate form of expression (1) is

$$F_J(\theta) \propto 1 + (\mu H/kT)^2 (k_1 \cos^2\theta + k_2 \cos^4\theta + \ldots + k_p \cos^{2p}\theta).$$

Here $p \leqslant J$; the constants $k_1, \ldots k_p$ are, of course, also undetermined.

These formulæ do not include the deflecting effect after emission of the magnetic field on the emitted particle (if charged), as this effect depends on the experimental arrangement, and can be calculated classically since the de Broglie wave-length of the particles will be small compared with the dimensions of the apparatus.

A more detailed method has also been used to calculate the angular distribution of γ-rays emitted from oriented nuclei in a 2^l-pole transition; this method is also being applied to alpha and beta emission.

Let $F_{JJ'}(\theta)$ denote the angular distribution resulting when a nucleus of initial spin J emits a 2^l-pole γ-ray and the final nucleus has spin J'. Then

$$F_{JJ'}(\theta) = \sum_{M=-J}^{+J} \epsilon^{M\beta} \sum_{M=-l}^{+l} \left(c_{M-m,m}^{JJ'l}\right)^2 . T_{lm}(\theta),$$

where

$$I_{lm}(\theta) = \tfrac{1}{2}(l-m+1)(l+m)(P_l^{m-1})^2 + m^2 (P_l^m)^2 + \tfrac{1}{2}(l+m+1)(l-m)(P_l^{m+1})^2.$$

Here M is z minus component of total angular momentum J of initial nucleus; m is z minus component of total angular momentum l of emitted photon (that is, $m = -l, -l+1, \ldots, +l$); P_l^m is a normalized associated Legendre function of order l; β has the same meaning as above.

The coefficients $c_{M-m,m}^{JJ'l}$ are those which occur in the group theoretical derivation of the formulæ for the 'vector addition' of quantized angular momenta. They may be calculated from the formula,

$$c_{m_1 m_2}^{j_1 j_2 J} = \sum_{\nu=0}^{\lambda} (-1)^{\nu} \frac{\sqrt{\{(j_1+m_1)!\,(j_1-m_1)!\,(j_2+m_2)!\,(j_2-m_2)!\,(J+M)!\,(J-M)!\}}}{(j_1-m_1-\nu)!\,(j_1+m_1-\lambda+\nu)!\,(j_2+m_2-\nu)!\,(j_2-m_2-\lambda+\nu)!\,\nu!\,(\lambda-\nu)!}$$

where $\lambda = j_1 + j_2 - J$ and $M = m_1 + m_2$ (see Van der Waerden[3]).

The expression for angular distribution has been evaluated in the case of dipole transitions ($l = 1$). In this case we can have $J' = J+1$, J, $J-1$, and then, provided $J \geqslant 1$ (there are no effects for $J = 0$ or $\frac{1}{2}$),

$$F_{J,J+1}(\theta) = 1 + \left(\frac{H\mu}{kT}\right)^2 \cdot \frac{1}{40} \cdot \frac{2J-1}{J} \cdot \cos^2\theta,$$

$$F_{J,J-1}(\theta) = 1 + \left(\frac{H\mu}{kT}\right)^2 \cdot \frac{1}{40} \cdot \frac{(J+1)(2J+3)}{J^2} \cos^2\theta,$$

$$F_{J,J}(\theta) = 1 - \left(\frac{H\mu}{kT}\right)^2 \cdot \frac{1}{40} \cdot \frac{(2J-1)(2J+3)}{J^2} \cos^2\theta,$$

provided in each case $H\mu/kT \ll 1$.

Inserting numerical values, we may write

$$F_{JJ'}(\theta) = 1 + 3{\cdot}34 \times 10^{-11} \left(\frac{H(\text{kilogauss}) \times \mu(\text{nuclear magnetons})}{T(^\circ\text{K.})}\right)^2 f(J, \delta J). \cos^2\theta.$$

Some values of $f(J, \delta J)$ are given in the table below:

δJ	$f(J, \delta J)$	Values of $f(J, \delta J)$ $J=1$	$3/2$	$9/2$	$11/2$
$+1$	$(2J-1)/J$	1	1·3	1·8	1·8
-1	$(J+1)(2J+3)/J^2$	10	6·6	3·3	3·0
0	$-(2J-1)(2J+3)/J^2$	−5	−5·3	−4·7	−4·6

If we take, say,

$T(^\circ\text{K.}) = 0{\cdot}01$;
$\mu(\text{nuclear magnetons}) = 3$;
H/K gauss $= 100$;

the resulting departure from spherical symmetry is of the order of $0{\cdot}03\,f$, that is, it lies between 3 and 30 per cent.

No definite conclusions can, of course, be drawn from this last calculation as to the magnitude of the effect in the case of higher multipole emission, though it seems possible that this will be of the same order as in the dipole case.

I would like to express my thanks to Prof. M. H. L. Pryce for the interest he has taken in these calculations.

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Capture of Negative Mesons by Nuclei

SEVERAL writers[1] have commented on the unexpectedly long period which has been found for the nuclear capture of negative mesons from cosmic radiation at low altitudes (about 10^{-6} sec. in aluminium[2]). It has been estimated[3] that if this radiation fell on matter, the mesons would take about 10^{-12} sec. to be slowed down by Coulomb interactions and to fall into 'K-orbits' around the nuclei. Consequently, the experimental value of 10^{-6} sec. is the period for nuclear capture of a meson from the K-orbit[4], in marked contrast to the value of 10^{-16} sec. or less which has been predicted[3] on the assumption that nuclear particles interact with each other through this meson field alone (apart from Coulomb interaction). The estimate of 10^{-12} sec. for the slowing-down time has been questioned by Fröhlich[5], but it seems to be generally believed that the time taken is much less than 10^{-6} sec. and that there is, in fact, a big discrepancy between the experimental and theoretical values for the nuclear capture period.

It has been suggested[6,7] that the observations can be explained on the hypothesis that there are two kinds of meson: a heavy meson which interacts strongly with nuclear particles and which does not penetrate appreciably to sea-level, and a light meson which interacts only weakly with nuclear particles and which is found at low altitudes. The observations of Powell and co-workers[7] suggest that the heavy meson is capable of disintegrating spontaneously into a light meson and a neutral particle of comparable mass; other experimental evidence indicates that the light meson is also unstable, decaying spontaneously with a half-life of about 2×10^{-6} sec.[8] into an electron and, presumably, a neutral particle. (Recent experiments by Hincks and Pontecorvo[9] indicate that this neutral particle, if it exists, ionizes less strongly than a gamma-ray.)

It is tempting to suppose that the interaction of the heavy mesons with nuclear particles is connected with the nuclear forces and that there is no *direct* coupling between the light mesons and nucleons. There is, however, an indirect interaction between light mesons and nucleons by virtue of the coupling implied in the disintegration of heavy mesons into light mesons. According to the hypothesis which we wish to discuss, positively and negatively charged heavy mesons exist, which differ only in their electric charge and which are to be identified with Powell's π- and σ-mesons respectively. For the present discussion, we shall use the single symbol π to represent them. We use the symbol μ to denote a light meson of either charge, and ρ the neutral meson associated with the disintegration of π-mesons.

The μ-decay of the π-meson can be written in symbolic form

$$\pi\text{-meson} \rightarrow \mu\text{-meson} + \rho\text{-meson}. \qquad (A)$$

Most theories of neutral particles lead to the conclusion that, if such a reaction is possible, then so is the reaction:

$$\mu\text{-meson} \rightarrow \pi\text{-meson} + \rho\text{-meson}. \qquad (A')$$

The forces between nuclear particles are due to reactions of the type

$$\text{neutron} \rightarrow \text{proton} + \pi^-\text{-meson}. \qquad (B)$$

We can now assume that the reactions

$$\begin{array}{ccc} & \text{Proton} + \pi^-\text{-meson} + \rho\text{-meson} & \\ \nearrow & & \searrow \\ \text{Proton} + \mu^-\text{-meson} & & \text{Neutron} + \rho\text{-meson} \\ \searrow & & \nearrow \\ & \text{Neutron} + \pi^+\text{-meson} + \mu^-\text{-meson} & \end{array} \qquad (C)$$

account for the nuclear capture of μ^--mesons, in contrast to the reaction

$$\text{proton} + \mu^-\text{-meson} \rightarrow \text{neutron}$$

on which the estimate of 10^{-16} sec. mentioned above was based. In consequence of our assumption of zero direct coupling between nucleons and μ-mesons, we would have zero probability for such a one-stage reaction; we must have recourse to a second-order perturbation calculation with intermediate states as shown in (C).

For the sake of obtaining orders of magnitude for the half-lives of reactions A and C, we consider the case in which the meson wave-functions are scalar and the interaction terms involve no derivatives. We then find that the half-life τ for spontaneous disintegration of a π-meson (of either charge) at rest (A) is given by

$$\frac{1}{\tau} = \frac{1}{8\pi} \frac{f^2\hbar^3}{m_\pi^2 c} \frac{m_\mu c^2}{\hbar} \frac{v_\mu}{c}, \qquad (1)$$

where f is the coupling constant for the reaction (A), m_μ, m_π are respectively the masses of the μ- and π-mesons and v_μ is the velocity with which the μ-meson is emitted. We estimate that the half-life τ_c for nuclear capture of a μ-meson from the 'K-orbit' through the mechanism (C) is given by

$$\frac{1}{\tau_c} \sim \frac{1}{4\pi^2} \frac{f^2\hbar^3}{m_\pi^2 c} \frac{g^2}{\hbar c} \left(\frac{e^2}{\hbar c}\right)^3 Z^4 \left(\frac{m_\mu}{m_\pi}\right)^2 \frac{m_\rho c^2}{\hbar} \frac{p_\rho}{m_\rho c}, \qquad (2)$$

where g is the coupling constant for reaction B, Z is the atomic number and m_ρ, p_ρ are respectively the rest mass and momentum of the emitted ρ-meson. In obtaining this estimate, we performed the calculations for the case of a free μ-meson; we then assumed that the probability per second for capture from the K-orbit was proportional to the probability density near the nucleus, given by the ordinary wave mechanics of a Coulomb centre of attraction. The result then also depends on the square magnitude of a nuclear matrix element, similar to those occurring in the theory of nuclear β-decay; the value of this matrix element will depend on the initial and final nuclear states and may accordingly be difficult to compute very accurately. It seems plausible to us to assume the value Z for the square magnitude of this matrix element, averaged over the initial nuclear states and summed over the final ones.

Substituting the following numerical values in (1) and (2): $Z = 13$, $\tau_c = 10^{-6}$ sec.[2], $e^2/\hbar c = 1/137$, $g^2/\hbar c = 0{\cdot}1$ (from the strength of nuclear forces), $m_\pi/m_\mu = 1{\cdot}6$ (Powell's latest results are $m_\pi/m_\mu = 1{\cdot}64 \pm 0{\cdot}11$, $m_\mu/m_e = 205 \pm 20$ [10]), $p_\rho/m_\rho c = 1$, m_ρ/m_μ

$= \frac{1}{2}$ (our estimates based on Powell's results for m_π/m_μ), and $\nu_\mu/c = \frac{1}{2}$ (from Powell's results[7]); we obtain the value 10^{-14} for $f^2\hbar^3/m_\pi{}^2c$, the dimensionless constant for the strength of the π-meson interaction with the μ- and ρ-meson fields.

This gives 4×10^{-6} sec. for τ, the half-life for spontaneous μ-decay of the π-meson.

Marshak and Bethe[8] have estimated that the available experimental data impose upper and lower limits of 3×10^{-7} sec. and 4×10^{-11} sec. respectively on the value of τ; the upper limit may with less certainty be reduced to 2×10^{-8} sec. Our estimate for τ agrees with these figures, showing that the theory discussed above is consistent with the value of 10^{-6} sec. for τ_c.*

Other similar theories can be formulated; indeed, if one assumes (as we did above) that the π-mesons alone have direct coupling with nucleons, then the data on nuclear forces can probably best be explained by taking a pseudoscalar wave function to describe the π-meson field. Any variations of this type would probably not alter the above estimates for τ by more than a factor of ten, and consequently such theories would probably also be consistent with the above-mentioned data. Marshak and Bethe[8] have shown that the above data can be accounted for on a similar theory; on their theory a π-meson decays into a μ-meson and a neutrino, and nuclear particles have a direct coupling to both π-meson and neutrino fields.

Another consequence of the above theory may be noted. The experimental evidence indicates that the scattering of negative μ-mesons by nuclei is effectively due to the Coulomb forces alone. The very small value for the interaction constant $f^2\hbar^3/m_\pi{}^2c$ which we obtained above shows that on this theory the effects of 'π-meson forces' on the nuclear scattering of μ-mesons are indeed negligible compared with the effects of Coulomb forces.

I wish to thank Prof. Pryce for suggesting these calculations and for helpful discussions.

* *Note added in proof.* Our estimate agrees with the value $\tau = 6 \times 10^{-6}$ sec. suggested recently (Greisen, K. I., *Phys. Rev.*, **73**, 521; 1948) to explain the experimental data on the energy spectrum of heavy mesons far underground.

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Cloud Chamber Investigation of Straggling of Short-Range Particles Produced by Slow Neutron Reactions

A study of the range distribution of particles produced by slow neutron disintegrations of gas nuclei in a cloud chamber offers especially favourable conditions for determining the straggling coefficient since, in such circumstances, the difficulty of producing a source of homogeneous particles is avoided.

In previous investigations of the reaction energy in slow neutron processes[1], a cloud chamber was used which was filled with air at low pressure or with a gas mixture containing the vapour of boric acid ester; the following reactions were studied:

$$^{14}_{7} + {}_{0}n \rightarrow {}^{14}_{6}C + {}^{1}_{1}H, \qquad (1)$$

$$^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{7}_{3}Li^{*} + {}^{4}_{2}He, \qquad (2)$$

where $^{7}_{3}Li^{*}$ denotes the $^{7}_{3}Li$ state of 0·45 MeV. excitation energy. By a careful examination of the tracks, it is possible to discriminate those produced in the disintegrations of boron or nitrogen from the background tracks due to gas atoms (hydrogen or helium atoms) set in motion by fast neutrons. The distributions of the total ranges are given in the histograms Figs. 1 and 2.

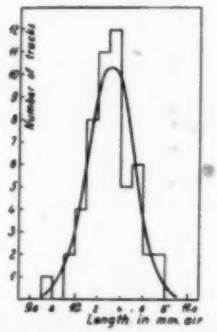

Fig. 1. Distribution of total ranges of 54 tracks produced by the reaction ^{14}N (n,p) C^{14}

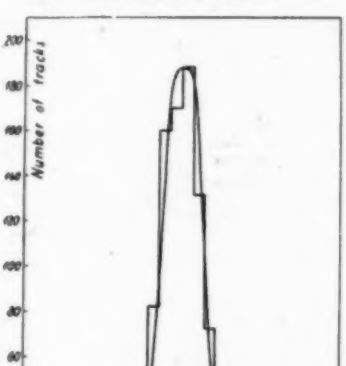

Fig. 2. Distribution of total ranges of 926 tracks produced by the reaction ^{10}B (n,α) ^{7}Li

The range distribution $W(R)$ in Fig. 1, corresponding to reaction (1), can be fitted to a Gaussian curve

$$W(R) = \frac{1}{\sqrt{2\pi}\Omega} \exp - \frac{(R - R_0)^2}{2\Omega^2}, \qquad (3)$$

and leads to a straggling coefficient $\Omega = 0{\cdot}20$ mm. The mean ranges of the protons and the ^{14}C particles are found to be 10·0 and 0·3 mm. of air at N.P.T., respectively, and since the contribution of ^{14}C to the straggling must be expected to be small, we find for the relative straggling coefficient of the protons

$$\left(\frac{\Omega}{R_0}\right)_H = 0{\cdot}020.$$

This result is in good agreement with the theory[2] according to which the straggling for protons of not too short range, where the effect is primarily due to electronic collisions, should just be about 2 per cent, approximately independent of range and stopping material.

The range distribution in Fig. 2 could not be represented by a simple Gaussian curve, since the histogram is distinctly unsymmetrical. This circumstance may be taken as an indication that nuclear collisions contribute appreciably to the straggling effect. In fact, in this case, the possibility of the particle losing a comparatively large part of its energy in a single encounter may give rise to a dissymmetry in the straggling curve of the type found.

The straggling curve may, in such cases, be interpreted as an approximately Gaussian peak with a tail extending considerably beyond the peak towards smaller R-values[3]. For the measurements shown in Fig. 2, representing the distribution of total ranges for a helium and a lithium particle combined, the tail is estimated to contain about 15 per cent of the tracks. (The tail is somewhat depressed, since tracks containing side branches of more than 0·2 mm. of normal air were excluded from the statistics.)

The best fit to the Gaussian peak corresponds to a width Ω^* of 0·16 mm., leading to a relative straggling coefficient of

$$\frac{\Omega^*}{R_0} = 0{\cdot}014.$$

Under the experimental conditions it was not possible to ascertain at what point of the track the boron disintegration takes place, and the individual straggling coefficients for the helium and lithium particles cannot, therefore, be obtained. If the two relative straggling coefficients were equal, a simple calculation gives about 0·02 for each when taking into account that the mean ranges are estimated to be 7·0 and 4·35 mm. for the helium and the lithium particles[4], respectively. This result obviously implies that, for one of the particles, the relative straggling is at least about 2 per cent. The theoretical estimates of the contribution of electronic collisions to the straggling give, however, only about 1 per cent and ¾ per cent for α-particles and ^{7}Li nuclei, respectively.

Whereas the straggling of the protons by reaction (1) could be accounted for by electronic collisions, it thus appears that the width as well as the shape of the experimental straggling curve, corresponding to the process (2), give evidence of an essential contribution of nuclear collisions. This circumstance is in accordance with general theoretical arguments, according to which the relative importance of nuclear collisions on stopping and straggling increases rapidly with increasing charge and decreasing velocity of the penetrating particle. Further measurements to improve the analysis of the range distributions are going on, and it is hoped thereby to obtain more detailed estimates regarding the straggling effect of nuclear collisions.

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A Doubly Charged Cosmic Ray Particle

Among more than a thousand stereoscopic counter-controlled cloud chamber photographs of mesons which we have obtained during the past six months while studying the scattering of mesons of different energies in lead plates, we have obtained the photograph reproduced herewith. Each one of the stereoscopic cameras made an angle of 22½° with the normal to the chamber. The chamber was triggered by a triple coincidence Geiger – Müller counter system with 25 cm. of lead below the chamber and above the lowest counter, so at least one of the particles must penetrate 25 cm. of lead. There was no lead on the top of the chamber. The usual argon–alcohol mixture was used in the chamber.

Heavily ionizing doubly charged particle ejected from the lead plate by a neutral particle and accompanied by electrons and mesons

The photograph reproduced and its stereoscopic partner show several cascades produced by electrons in the 2-cm. lead plate inside the chamber, accompanied by penetrating particles which have gone through the plate without appreciable deflexion. They also contain a thick track (*a*) which emerges from the bottom of the lead plate and is produced by a particle accompanying the electrons and the penetrating particles.

A careful stereoscopic re-projection of this thick track through the lead plate into the top of the chamber shows that it would lie just within the illuminated region near the lead plate, and would thus be visible if it were a heavily ionizing particle going right through the lead plate. The heavily ionizing particle therefore appears to have been produced by a non-ionizing ray entering the top plate and accompanying the other electrons and mesons in the shower. Careful consideration shows that the heavily ionizing particle is probably doubly charged.

The heavy track shows four delta-rays along its length, of which two have ranges in air of 0·75 cm.–1 cm. From this it can be calculated that their energy must be between 20 and 25 keV., and hence they must have a velocity v approximately equal to 0·3 c, c being the velocity of light. The heavy track must be due to a particle of mass large compared with

that of an electron. Hence the minimum velocity of the particle must be $v/2 \cos \theta$, θ being the angle which the delta-ray makes with the heavy track. This angle is 45° in the present instance. It follows that the velocity of the particle must be at least $0{\cdot}21\ c$, and so the density of ionization of this particle could be at most eleven times the minimum density of ionization if it were singly charged. The density of ionization of a doubly charged particle of the same velocity would be four times the above value, namely, forty-four times the minimum. The average density at the end of the range of the delta-ray track ($v = 0{\cdot}1\ c$) would be of the order of forty to fifty times the minimum density of ionization, and from the present photograph and other enlargements of the track it can be seen that the density of the main track is at least of the same order as that of the delta-rays, namely, forty to fifty times minimum, which is about the same as that of a doubly charged particle. Therefore, we conclude that the heavily ionizing particle must be doubly charged.

It is possible that it is an α-particle thrown out of an explosion process; if it were so, its energy would be 80×10^6 eV. Since the origin of this particle is in the back portion of the lead plate, and since it is coming towards us, it is possible that the other explosion particles, if any, have gone to the back of the chamber and so out of the field of view. The particle might also be a doubly charged proton[1]. The importance of the photograph is, however, that it shows that a doubly charged particle has been ejected by a neutral particle accompanying a shower of electrons and mesons.

It must be noted that similar heavy tracks have been obtained by others[2,3]. But it is remarkable that this photograph of a rare event was obtained at sea-level in a total of only a thousand pictures. The other small thick track to the left of the particle (*a*) is possibly a superposition of two tracks in the direction of the camera. Unfortunately, this track in the right-hand stereophotograph has been completely obscured by the bright background.

I have great pleasure in acknowledging my thanks to Prof. H. J. Bhabha for his guidance and suggestions on the analysis of the photograph.

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Interpretation of Data from Electrical Resistivity Geophysical Surveys

Electrical resistivity surveys are all based on the method of Wenner[1]. A current, I, is passed into the earth through one point electrode and returns to the apparatus through a second. The potential difference between two points on the earth's surface, V, is measured. Let

$$R = V/I. \qquad (1)$$

Then R can be related to the resistivity of the earth and the electrode spacing. Usually the four electrodes used are spaced in a straight line, and frequently a symmetrical arrangement is used. If the distance between the current electrodes is $2a$ and between the potential electrodes is $2\alpha a$ for a symmetrical arrangement, it is easily shown[2] that, for a homogeneous earth, the resistivity ρ is given by

$$\rho = \pi a \frac{(1 - \alpha^2)}{2\alpha} R. \qquad (2)$$

If the earth is not homogeneous, the value of ρ obtained from (2) will vary with a. This variation will be related to the nature of the earth, and hence the usefulness of the method.

The theory of the variation of ρ for different earth structures has been considered by many authors. The general conclusion is that the mathematical treatment is excessively complex for any but the simplest structures. Further, the number of parameters entering into the equation becomes large, and this alone would make the interpretation of practical curves difficult. The case of an earth composed of parallel layers of homogeneous material is of especial interest as other geophysical methods are not suitable. For this case it has been shown[2,3] that the more complex earths can be approximated to by the use of the solution of the two-layer case.

For this case, Hummel[2] has shown that

$$\frac{\rho}{\rho_1} = 1 + \sum_{n=1}^{\infty} k^n \left\{ \frac{1/\alpha + 1}{\sqrt{1 + \left(\frac{2nh}{a(1-\alpha)}\right)^2}} - \frac{1/\alpha - 1}{\sqrt{1 + \left(\frac{2nh}{a(1+\alpha)}\right)^2}} \right\}, \qquad (3)$$

where $k = (\rho_2 - \rho_1)/(\rho_2 + \rho_1)$ = reflexion factor; (4)

and h is the thickness of the upper layer of resistivity ρ_1 and the lower layer has a resistivity ρ_2 and an infinite depth. This curve has no maximum or minimum and so it is difficult to fit it to field results.

A method of applying (3) to practical cases has been suggested by Tagg[3], but this involves considerable calculation on each occasion it is used. On the suggestion of Prof. L. S. Palmer, the point of inflexion of (3) was found as a function of k and α. This method was abandoned because of the difficulty in calculating the point of inflexion and also the difficulty of obtaining it from experimental data.

Further investigation suggested that a graphical method of solution was possible. Referring to (3), it will be seen that all curves for a given k and α can be reduced to the same form by plotting ρ/ρ_1 against a/h. As h is the unknown on which most interest is centred, this cannot be done directly. If, however, a set of curves of $\log \rho/\rho_1$ against $\log a/h$ for different values of k and the constant α (universal curves) is prepared, these can be used to interpret logarithmic plots of the experimental results. The logarithmic plot will be identical with the universal curve with the same value of k except that the axes will be displaced by $-\log h$ and $-\log \rho_1$ from the $\log \rho/\rho_1$ and $\log a/h$ axes respectively.

By adopting a standard scale for the graphs and working with a constant α, the universal curves can be plotted on transparent material and the axes marked. The transparency is then fitted over the experimental graph and the position of the axes of the universal curves give h and ρ_1 directly, and k is found from the actual universal curve used. The computation of universal curves is simplified by using the tables of Roman[4].

The universal curves can be used for multilayer earths to the same degree of approximation as the methods discussed by Hummel and Tagg, and, in fact, this approximation can be rapidly and easily accomplished.

This method has been used on four experimental curves obtained by L. S. Palmer. In one case, borehole data were available and the result was in excellent agreement for the depth of the layer.

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Annealing of Glass

S. M. Cox[1] has considered the departure from the 'Maxwellian' law of the annealing-rate in glass. He attributes that part of the discrepancy which cannot be accounted for on the basis of a progressively changing viscosity to changes in the equilibrium condition of the glass under the action of the stresses present. An expression for the rate of release of stress is obtained, based on a theoretical derivation of the laws governing these changes and the rate of approach to equilibrium. Unfortunately, in his brief account only the final expression is given, so that it is not possible to comment on the derivation, nor on the extent to which a fit with Morey's experimental results provides a confirmation of the theory.

However, these approaches to an equilibrium condition in the presence of stresses are well known as observed phenomena, appearing as the 'delayed elastic effects' in ordinary experiments. Under constant stress, glass and many other substances obey the following expression :

$$\text{strain} = a + bt + c.f(t),$$

where a, b, c are constants proportional to the stress and dependent upon the temperature, composition, etc. The three terms represent respectively the instantaneous reversible elastic strain, the irreversible purely viscous flow at constant rate, and the reversible delayed elastic strain. The function $c.f(t)$ has the value 0 at $t = 0$ and c at $t = \infty$.

It is scarcely surprising that the rate of release of stress during annealing is not 'Maxwellian', when it is remembered that Maxwell's equation of viscoelasticity (which suggests the 'Maxwellian' or exponential rate of release of stress) reduces to an expression for the behaviour under constant stress which does not include any delayed elastic effect, namely : strain $= a + bt$. The original theory of annealing, in fact, considered only relaxation of stress through the mechanism of viscous flow. The representation of the more complicated behaviour of real materials has, however, been extensively discussed (see, for example, Alfrey and Doty[2]), and it is possible to derive a theoretical 'stress release' curve from any 'creep' curve obtained under constant applied stress, and vice versa.

I have recently shown[3], by considering the mechanism of the annealing process and the experimental data on the delayed elastic effects in glass, that it would be possible on this basis to account for the discrepancies remaining in the theory of annealing. I pointed out also that a further complication existed, since the rate of release of stress must depend partly on the form of the previous cooling schedule for the glass, during which partially developed delayed elastic strains might have been 'frozen-in'. Experimental data in this field are at present insufficient for a quantitative formulation of the annealing laws.

The description of the phenomena proposed by Mr. Cox appears to be analogous to the explanation of delayed elasticity under uniform compression described by Frenkel[4]. It is of interest that this explanation, and apparently Mr. Cox's theory, both lead to a single exponential term of the form $\{1 - \exp(-t/\tau)\}$ for $f(t)$, although the experimental results on the ordinary delayed elastic effects can only be represented as the sum of a number of such terms with differing coefficients and 'relaxation times'. For glass the function is probably of the form $\{1 - \exp(-\sqrt{t/\tau})\}$, which implies a continuous distribution of such terms. There are other discrepancies between this theory and the experimental facts, and added complications in considering stresses, such as shear stresses, which do not involve a change in volume. It is more satisfactory to look to the existing (although incomplete) experimental data for an explanation of the anomalies in the annealing process.

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It is true that such theoretical work on problems associated with annealing of glass must be of a tentative nature until adequately supported by experiments, but its value lies in that it provides guidance for the design and interpretation of experiments. Without such guidance there is, for example, confusion between delayed elasticity and viscosity change with time ; the influence of stabilization with respect to temperature is also enigmatical. In Dr. Jones's own experiments[1] no attempt was made to stabilize the glass with respect to temperature. His results are particularly interesting for this very reason, because in his bending test—involving an averaged effect for both tension and compression together—there are theoretical grounds for supposing concurrent temperature stabilization to be without influence. Dr. Jones, in finding this experimentally, erroneously concludes the effect to be absent.

A feature which reduces the usefulness of the experimental results is that glasses of different composition have been used, and unfortunately there is a sparsity of experimental work on 'dilute' silica glasses—the study of which is most likely to be amenable to theoretical treatment.

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Failure of Adrenal Cortical Extracts to Cause Lysis of Living Lymphocytes *in vitro*

In a series of papers by Dougherty, White and Chase, it has been claimed that the rate of lymphoid tissue dissolution is under the control of the adrenal cortex[1–3], and that injections of pituitary adrenocorticotropic hormone or adrenal cortical extract accelerate this dissolution and release antibody globulin which, it has been claimed by themselves[4,5,7,8,6] and by other workers[9,3] is present in the lymphocytes. The evidence adduced by Dougherty, White and Chase in support of this contention was the histological finding of cellular destruction and increased phagocytic activity in the lymphoid organs, and the reduction of weight of these organs, which they[10] and others[11–14] had shown to follow such injections. The present work was undertaken to investigate by quantitative methods the action of adrenal cortical extracts on lymphocytes, and to determine whether any direct lytic effect could be demonstrated.

Adult albino rats were bled from the heart into a sterile paraffined syringe, the blood allowed to clot in a 'Pyrex' tube and the serum removed. Next day the inguinal lymph nodes of the animal were removed with aseptic precautions; and macerated in sterile Simms'[15] saline solution containing 5 units of crystalline sodium penicillin per ml. By this means a suspension of cells comprising approximately 96 per cent lymphocytes was obtained. The suspension was centrifuged in a sterile tube at a slow speed to throw down the cells and to separate fat and cell fragments. The supernatant was discarded and replaced with a nutrient fluid consisting of equal volumes of the homologous serum and Simms' saline solution, the latter containing penicillin (5 units/ml.), and the appropriate dilution of the hormone preparation under test. After mixing, the tubes were incubated at 37° C. for 8–12 hours in an atmosphere of 95 per cent oxygen and 5 per cent carbon dioxide. Sterile samples were withdrawn at intervals after careful resuspension of the cells, and the cell population enumerated. Control tubes containing hormone inactivated by prolonged heating, and others of serum and saline only, were set up for each experiment.

Two adrenal cortical preparations were employed: 'Eschatin' (Parke Davis and Co., Ltd.) (for which I am indebted to Dr. J. Stanley White of Parke Davis and Co.) and 'Eucortone' (Allen and Hanbury, Ltd.). In one series of experiments the hormone ('Eschatin') was added directly to the nutrient medium in concentrations ranging from 1 : 500 to 1 : 10,000. In another series the animal was given a large dose (1–2 ml.) of hormone ('Eschatin' or 'Eucortone') by intraperitoneal injection three hours before withdrawing blood for the preparation of serum.

The results were negative in all experiments but one. No significant diminution occurred in the number of lymphocytes in the suspensions in any of the tubes, except in one experiment in which heterologous and not homologous serum was employed. In this case the regression of lymphocyte density on time did show that a significant lysis of cells had occurred, even though many of the surviving cells exhibited active movements at the end of the experiment.

It was concluded that if adrenal cortical extract does act on the lymphocyte, its action is not directly to cause lysis of the cell. The recent reports of Eisen *et al.*[16] and of Stoerk, John and Eisen[17], that the adrenal cortex does not influence the level of circulating antibody or the turnover of serum protein, are also evidence against the conception of adrenal cortical control of antibody release from lymphocytes by causing lysis of the antibody-bearing cells.

The reduction in weight of the lymphoid organs reported by the investigators already mentioned above[11–14] to follow injections of pituitary adrenocorticotropic hormone or adrenal cortical extract, or the similar reduction in the weight of these organs occurring in the course of the alarm reaction of Selye[18,19], is explicable on the basis that the physiological action of the adrenal cortex on the lymphoid organs is not so much to cause lysis of adult cells as to control the maturation and mitotic-rate of young lymphocytes. However, with very severe sub-lethal stimuli the effect on the dividing cells may be so marked that actual cell destruction occurs, especially in the thymus, where the mitotic-rate is high.

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Formation of Oxime-Nitrogen in *Torula*-Yeast Fed with Potassium Nitrate

The question of the formation of hydroxylamine and oxime as intermediate products in the fixation of nitrogen has been under investigation for many years[1]. Formation of oxime-nitrogen has been established both with Azotobacters and higher plants when nitrate has formed the source of nitrogen nutrition. Examination of oxime-nitrogen is not easy because of its small amount and because the methods of analysis are not satisfactory, in particular, if the solutions to be examined are not quite colourless and clear.

In this Laboratory, synthesis of amino-acids was recently studied with low-nitrogen yeast (*Torula utilis*) by suspending yeast in ammonium sulphate solution (Roine[2]). A great increase was then noted in the soluble nitrogen of yeast due to amino-dicarboxylic acids and their amides as well as to alanine. Roine was not able to find other amino-acids; accordingly, his investigation supports the view that

the amino-dicarboxylic acids are formed as primary amino-acids in accordance with the findings regarding nitrogen fixation.

Recently, we have carried out corresponding experiments by suspending low-nitrogen yeast (*Torula utilis*) in a 1·5 per cent solution of potassium nitrate. The increase of amino-dicarboxylic acids, their amides, and alanine in yeast was similar to that with ammonium sulphate feeding. Besides, a very rapid formation of oxime-nitrogen was observed. The maximum amount of oxime-nitrogen was attained in about ten minutes, after which a drop followed. The procedure employed was as follows: low-nitrogen yeast was suspended in nutrient solution free from sources of nitrogen and carbon, potassium nitrate was added to a concentration of 1·5 per cent and a vigorous current of air was passed through the suspension. Samples taken at different intervals were put in centrifuge tubes placed in ice, centrifuged and washed once with ice-cold water. Twice the volume of trichloracetic acid (8 per cent) was added and the acid suspensions were allowed to stand in an ice-box for 24 hours, centrifuged, filtered through a Jena glass filter and the clear solution was used for determinations. Centrifugation and washing the yeast took about twenty minutes; decomposition of oxime possibly occurred during this time. The quantities of oxime-nitrogen found may thus represent only a part of the actual amount. Oxime-nitrogen was determined by hydrolysing with 3 *N* sulphuric acid for six hours in a boiling water-bath and determining hydroxylamine according to Blom[3]. The solutions were colourless and transparent, and determination of the red colour formed was easy. The intensity of the colour was measured with a photo-electric colorimeter. The accompanying table gives the results.

AMOUNTS OF OXIME-NITROGEN IN μGM. PER 100 GM. FRESH YEAST

No. of expt.	Time (min.) 0	5	10	15	20	30	60	240	Source of nitrogen and treatment of samples
	With low-nitrogen yeast								
1*	0			+		+	0	0	Potassium nitrate. Extraction with trichloracetic acid
2	0			70		44	47	41	
4	0	31	280		80	0			
5	0	49	84		57	42			
3	0			0		0	0	0	Potassium nitrate. Extraction with water after freezing
6	0	0	0		0	0			Ammonium sulphate. Extraction with trichloracetic acid
	With normal yeast								
7	0	54	167		31				Potassium nitrate. Extraction with trichloracetic acid.

* Oxime-nitrogen shown qualitatively only.

A very small amount of free hydroxylamine was found in every experiment where oxime was noted. It might have originated from oxime in trichloracetic acid solution. Nitrite, hyponitrite and nitrohydroxylamic acid, which also give the colour reaction, are quantitatively destroyed during 6 hr. on boiling with 3 *N* sulphuric acid[4]. Accordingly, only hydroxylamine is determined by Blom's method.

The results show that the low-nitrogen yeast kept in nitrate solution always contained oxime-nitrogen (Expts. 1, 2, 4 and 5), whereas the same yeast in 1 per cent ammonium sulphate solution did not give even a trace of oxime-nitrogen (Expt. 6). Yeast with normal protein content (normal yeast) also forms oxime-nitrogen from nitrate (Expt. 7). In this respect there seemed to be no difference between normal and low-nitrogen yeasts. Some hydroxylamine was found in addition to oxime; this, however, may have originated from the oxime in the trichloracetic acid solution. Oxime-nitrogen in the table comprises both free hydroxylamine and that set free by sulphuric acid hydrolysis. In some experiments the low-nitrogen yeast suspended in nitrate solution was frozen and then extracted with water in an ice-box. No oxime-nitrogen could then be detected (Expt. 3), or at the most only traces. Accordingly, detection of oxime-nitrogen requires that the reduction be rapidly inhibited, as will happen when the sample is placed in trichloracetic acid solution.

Torula grows on the surface of agar with hydroxylamine as its sole source of nitrogen in concentrations up to 1 : 5,000, the highest concentrations after adaptation. In the nutrient solution *Torula* did not grow in the hydroxylamine concentrations used. With nitrohydroxylamic acid *Torula* grows well also in solutions after an incubation period of about 20 hours. Some hydroxylamine is then formed. The growth depends probably on the formation of nitrite from nitrohydroxylamic acid.

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Bacterial Hydrolysis and Utilization of Polysaccharide-like Substances ('Mucin') in Saliva

AMONG the very heterogeneous bacterial population of the mouth are to be found large numbers of organisms such as streptococci, staphylococci and lactobacilli, which require some source of fermentable carbohydrate from which to obtain energy for growth and to maintain their normal metabolic processes. It has generally been assumed that, in the mouth, food constituents such as starch, after breakdown by salivary amylase (ptyalin), or simple sugars, provide this source. The observations presented in a preliminary form here show that some groups of organisms in raw saliva are able to break down and make available the salivary mucins themselves.

The amount of glucosamine, estimated after acid hydrolysis of the saliva by the method of Elson and Morgan[1], was used to measure the amount of polysaccharide present. This criterion was chosen rather than more obvious ones, such as the amount of reducing sugar or the total amount of sugar determined by Sørensen and Haaguard's method[2], since such measurements would also include any carbohydrate food constituents, for example, starch and sucrose, which might be present in the samples; glucosamine is a well-recognized constituent of many polysaccharides, including those present in the saliva.

The amount of glucosamine remaining in five samples of raw, unstimulated saliva after they had been incubated for various times was determined (see

BACTERIAL UTILISATION OF POLYSACCHARIDES ('MUCINS') IN SALIVA INCUBATED AT 37° C.

Time (in hr.)	Glucosamine hydrochloride (mgm./ml.) H.J.	A.P.	L.C.	H.F.H.	D.C.
0	0·55	0·43	0·42	0·21	0·27
24	0·42	—	0·22	0·09	0·12
48	0·18	0·10	0·20	0·01	0·05
72	0·08	0·09	—	—	—

table). The rate of disappearance of glucosamine was, in fact, shown to be paralleled by that of both total sugar and reducing sugar, the latter being measured after acid hydrolysis.

The utilization of glucosamine was completely inhibited by bactericidal substances such as phenol, toluene, thymol and penicillin, or by heating to 100° for five minutes. There was partial inhibition by 1 per cent glucose or maltose, but not by powdered solid starch.

In the presence of the bactericides, a substance accumulated in some samples which reacted as N-acetyl glucosamine in the Morgan and Elson[3] test. This substance was diffusible through 'Cellophane' and its liberation was due to enzymes associated with the cellular material present in the saliva, and not to enzymes formed by the salivary glands. The relation of the observed hydrolysis of the polysaccharides to the breakdown of the 'blood group substances'[4,5,6] present in relatively high concentration in the saliva of 'secretors'[6] is of interest.

The significance of these observations in connexion with the well-known pathological conditions of the mouth is, of course, unknown; but it is clear that organisms in stagnation areas would be able to obtain considerable amounts of fermentable material by breaking down the salivary mucins.

I should like to express my thanks to Mr. A. Parkinson for his enthusiastic and competent technical assistance during the work.

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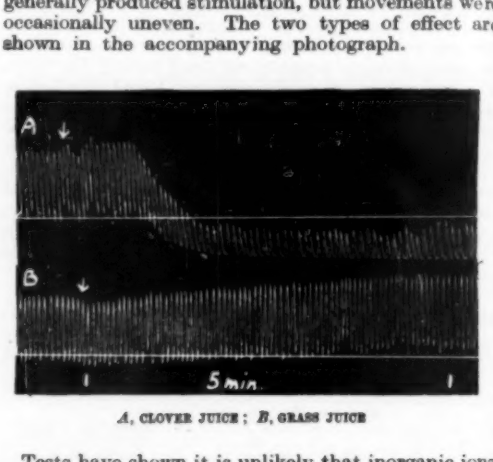
A Possible Relation Between the Action of Clover Juice on Isolated Muscle and 'Bloat' in Cattle

THE disturbance known as bloat, or hoven, in cattle arises through the inability of the animals to expel the gases formed in the rumen. Bloat can be expected when cattle graze young luscious clover or lucerne, but occasionally young grass can also cause the trouble.

A favoured view of the cause of bloat is that the muscles of the rumen wall lapse into relative immobility in the absence of adequate fibre in the diet and so fail to urge the gases to the œsophagus. Another view is that an allergic shock, resulting from some food constituent, may cause a spasm of the smooth muscle of the cardiac sphincter and so prevent escape of gas. In view of the possible association between bloat and rumen muscle activity, experiments were carried out to see if various herbage juices have any action on isolated smooth muscle.

Using rabbit intestine in Tyrode solution, twelve juices of legumes (*S* 100 white clover, wild white clover and lucerne) and nine grass juices were tested. One *S* 100 white clover was taken from a field in which two cows had just died through bloat. Very marked differences were obtained: the legume juices, when added in quantities of 0·7–2 ml. to a Tyrode bath of 55 ml. capacity, caused a rapid and very marked diminution in the amplitude and frequency of the gut movements. In some cases 2 ml. juice almost completely arrested the movements. At times this partial paralysis was accompanied by a relaxation of the muscle, as shown by a slight fall in the level of the tracing, or was occasionally preceded by a brief stimulation of movement.

Juices from two permanent pastures (one an irrigated pasture) gave effects resembling the clover, although the frequency of movements was not reduced. All other grass juices, from permanent grass and leys, gave quite different tracings. 1–2 ml. generally produced stimulation, but movements were occasionally uneven. The two types of effect are shown in the accompanying photograph.



A, CLOVER JUICE; *B*, GRASS JUICE

Tests have shown it is unlikely that inorganic ions are responsible for the clover effect, and attempts are being made to separate the substance or substances responsible.

Heat only partially reduces the effect, and the loss may be caused by absorption of material on protein precipitated by the heating. The active substance passes through a 'Cellophane' membrane. An alkaloid fraction showed no effect.

Preliminary tests have indicated that the addition of very small quantities of adrenalin to muscle affected by clover juice can cause recovery after a brief period. This observation needs confirming, but it is of interest since injections of adrenalin are commonly given to treat bloat in cattle.

The peculiar effect of clover juice may, or may not, be of significance in bloat; but further work on the isolation of the substance or substances appears justified. If this is achieved, direct animal confirmatory tests will be possible.

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PHARMACOLOGICAL ACTIVITIES IN DIFFERENT RODENT SPECIES OF *d*-TUBOCURARINE CHLORIDE AND THE DIMETHYL ETHER OF *d*-TUBOCURARINE IODIDE

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THE molecule of *d*-tubocurarine chloride contains two phenolic hydroxy groups as well as two methoxy groups attached to the aromatic nucleus[1]. The hydroxy groups can be alkylated; when they are methylated, the resulting dimethyl ether differs in a striking way from *d*-tubocurarine chloride in its pharmacological properties[2].

d-Tubocurarine chloride was treated with two molecular equivalents of sodium hydroxide and then with two molecular equivalents of methyl iodide, all in methanol solution. The solution was evaporated, acetone added, and the precipitate repeatedly extracted with boiling acetone. The acetone solution on evaporation left the dimethyl ether of *d*-tubocurarine iodide as a white to pale yellow crystalline residue. This was recrystallized from ethanol/ether. Analysis corresponded to the formula $C_{40}H_{44}O_6N_2I_2.3H_2O$.

The effect of a curarizing substance on the neuromuscular junction can be considered from the points of view of both its intensity and its duration. Our experiments show that the dimethyl ether of *d*-tubocurarine iodide differs markedly from *d*-tubocurarine both in the intensity and the duration of its effects on the neuromuscular junction in different species of rodents.

In the experiments reported here, the dimethyl ether of *d*-tubocurarine iodide has been compared with *d*-tubocurarine in the following ways: (1) in the intact mouse, rat and rabbit; (2) in a preparation of the rat, under nembutal anæsthesia, similar to that of Raventós[3], in which the contractions of the rectus femoris muscle, in response to repeated condenser discharges applied to its motor nerve at a rate of 25–50 per min., are recorded on smoked paper; (3) in the rat phrenic nerve-diaphragm preparation *in vitro*[4].

All the results given are based on the weights of hydrated salts. Since *d*-tubocurarine chloride has the formula $C_{38}H_{44}O_6N_2Cl_2.5H_2O$, the ratio of molecular weights of the dimethyl ether of *d*-tubocurarine iodide to *d*-tubocurarine chloride is as 1·22 to 1.

In the intact animal the effect of curarizing substances is indicated by the inability of the animal to right itself after being turned on its back or side. The dose at which 50 per cent of animals are thus paralysed (*ED*50) may be regarded as an inverse measure of the intensity of this effect. The duration of the paralysing effect can be measured directly. The results of comparative experiments with the two substances in intact animals are summarized in the table, in which the values for *ED*50 and *LD*50 and their standard errors in the mouse and the rat were estimated by the method of Miller and Tainter[5].

COMPARISON OF THE ACTION OF *d*-TUBOCURARINE CHLORIDE AND THE DIMETHYL ETHER OF *d*-TUBOCURARINE IODIDE IN THE INTACT MOUSE, RAT AND RABBIT. ADMINISTRATION BY THE INTRAVENOUS ROUTE

Substance	Test	Mouse		Rat*		Rabbit	
		Result (μgm./kgm.)	No. used	Result (μgm./kgm.)	No. used	Result (μgm./kgm.)	No. used
d-Tubocurarine	*ED*50	81·3 ± 7·2	32	55·6 ± 3·7	22	110–115	7
	*LD*50	200·6 ± 5·4	114	100·9 ± 2·6	31	200–210	6
Dimethyl ether of *d*-tubocurarine iodide	*ED*50	120·0 ± 2·1	42	13·6 ± 0·6	25	9–12	6
	*LD*50	206·3 ± 5·65	46	42·7 ± 2·1	22	30–33	6
Ratio of *ED*50 for the dimethyl ether compound to *d*-tubocurarine		0·7		4·1		9–13	
Ratio of durations of paralysis at 2/3 × *LD*50 for the dimethyl ether compound to *d*-tubocurarine		1		11		2–3	

* Young rats, weighing 35–65 gm.

In Fig. 1 the mean duration of paralysis in each species following the administration of various doses of *d*-tubocurarine or the dimethyl ether of *d*-tubocurarine iodide is plotted against the logarithm of the dose in μgm. per kgm. body-weight.

It is noteworthy that the duration of paralysis bears an approximately linear relationship to the logarithm of the dose over a considerable part of the dosage range in all three species and for both substances. It could, therefore, form the basis for a method of assay of either substance. As the slopes of the curves are a measure of increased duration of effect for unit increase of log-dosage, it can be seen that the slopes are inverse functions of the rates of elimination of the drugs, whether by destruction or excretion. Since the duration – log-dosage curves are not parallel, the durations of action of the two compounds have been compared in the table at the arbitrary dosage-level of two-thirds of the *LD*50.

In the Raventós preparation of the rat, the weight of the dimethyl ether of *d*-tubocurarine iodide required to reduce the tension of the muscular

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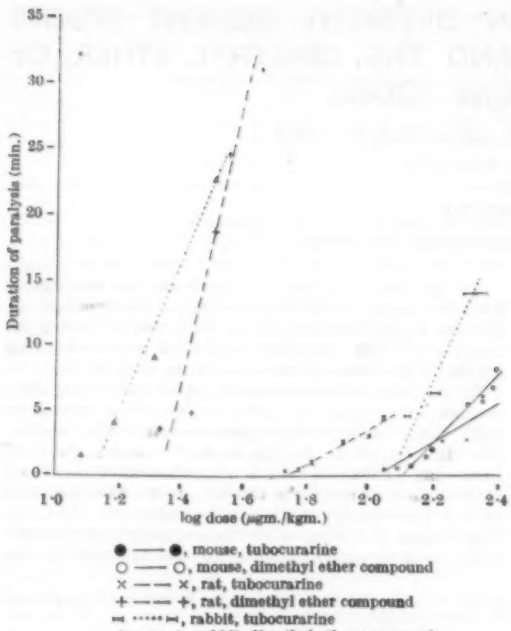
Duration of paralysis (min.)
log dose (μgm./kgm.)
●——●, mouse, tubocurarine
○——○, mouse, dimethyl ether compound
×——×, rat, tubocurarine
+——+, rat, dimethyl ether compound
▪ ····· ▪, rabbit, tubocurarine
△ ····· △, rabbit, dimethyl ether compound

Fig. 1. DURATION OF PARALYSIS FOLLOWING INTRAVENOUS ADMINISTRATION OF *d*-TUBOCURARINE AND THE DIMETHYL ETHER OF *d*-TUBOCURARINE IN THE INTACT MOUSE, RAT AND RABBIT

response to a given extent was one-third to one-half that of *d*-tubocurarine, when each drug was administered by jugular cannula. Administration of either drug below a threshold-level of dosage (about 8 μgm. of *d*-tubocurarine and 3 μgm. of the other compound in a 200-gm. rat) causes no reduction of muscular tension. When, however, two sub-threshold doses of 3 μgm. of the dimethyl ether compound were given to a preparation at an interval of 15 min., the second dose reduced muscular tension by 95 per cent (roughly to the same extent as a single dose of 6 μgm.). The existence of this threshold is in keeping with the fact that the individual muscle fibre obeys the all-or-none law. The summation of the sub-liminal depression of neuromuscular transmission, so clearly seen with the dimethyl ether of *d*-tubocurarine iodide (Fig. 2), is also consistent with this law.

In rat preparations of this type the reduction of muscular tension following administration of the dimethyl ether of *d*-tubocurarine iodide lasts very considerably longer than that following the administration of *d*-tubocurarine, as is seen in Fig. 2. As the dosage of both drugs is raised, so the ratio of duration of effect of the dimethyl ether compound to that of *d*-tubocurarine increases (cf. Fig. 1). The prolonged existence of the former in the circulation is shown by the fact that, after full recovery from a preliminary effective dose of this substance, a second dose (or a dose of *d*-tubocurarine) given within the limits of one to two hours has a greatly increased effect (see above). A similar cumulative effect is produced by a preliminary dose of *d*-tubocurarine, but it is very transitory.

Ligation of the renal arteries and veins in the Raventós preparation prior to the administration of either substance, increases the duration of action of each drug but does not prevent recovery of the muscular contraction. Thus, in a typical preparation with the renal vessels ligatured, a recovery of 20 per cent of the original tension of muscular contraction occurred 10 min. after administration of 14 μgm. of *d*-tubocurarine, while in another similar preparation 20 per cent recovery occurred 58 min. after administration of 4 μgm. of the dimethyl ether compound.

Efforts have been made to estimate the urinary excretions of the dimethyl ether of *d*-tubocurarine iodide and *d*-tubocurarine in the intact rat. Preliminary results suggest that the former is excreted quantitatively, while *d*-tubocurarine is not.

Using the *in vitro* method of Chou[4], it was found that the dimethyl ether of *d*-tubocurarine iodide was 3·3 times as active as *d*-tubocurarine on the rat's phrenic nerve-diaphragm preparation.

In the rabbit, the intensity of action of the dimethyl ether of *d*-tubocurarine iodide is many times greater than that of *d*-tubocurarine (see table), while the slopes of the two duration curves in Fig. 1 are closely similar, indicating that the two substances are removed from their site of action at similar rates. This shows that the dimethyl ether compound has a greater specific action at the myoneural junction in this species. It is noteworthy that both rates of elimination are low, suggesting that the rabbit lacks the special mechanism of the rat (see below) for dealing with *d*-tubocurarine (cf. McIntyre[6]).

The greater specific myoneural effect of the dimethyl ether of *d*-tubocurarine iodide is again shown in the rat, though to a somewhat lesser extent than in the

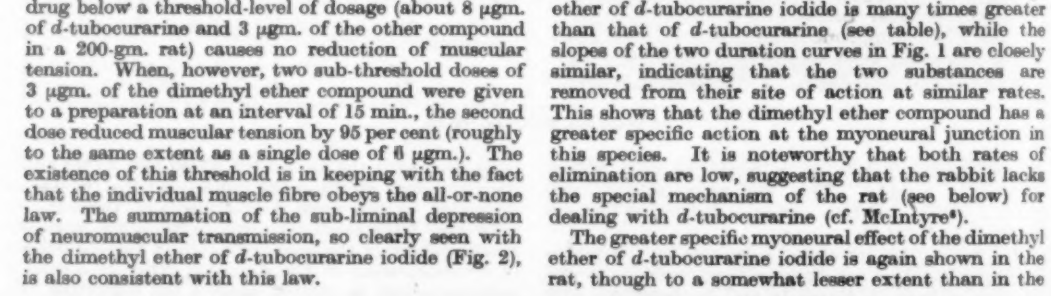

Fig. 2. CONTRACTIONS OF THE RECTUS FEMORIS OF THE RAT, IN RESPONSE TO THE APPLICATION OF REPEATED CONDENSER DISCHARGES TO ITS MOTOR NERVE, AFTER INTRAJUGULAR ADMINISTRATION OF (*a*) 10 μGM. OF *d*-TUBOCURARINE; (*b*) 4 μGM. OF THE DIMETHYL ETHER OF *d*-TUBOCURARINE IODIDE; AND (*c*) 3 μGM. OF THE DIMETHYL ETHER COMPOUND FOLLOWED 15 MIN. LATER BY A SECOND DOSE OF 3 μGM. IN (*c*) THE DRUM WAS STOPPED SEVERAL TIMES DURING THE RECOVERY PHASE

rabbit, by the *in vitro* experiments on the phrenic nerve-diaphragm preparation. In the intact mouse (see Fig. 1) it is seen that the myoneural junction is slightly less sensitive to the dimethyl ether compound than to *d*-tubocurarine, but the rate of elimination of the former is slightly less than that of the latter.

The fact that, in the rat *in vivo*, the duration of action of the dimethyl ether of *d*-tubocurarine iodide is many times greater than that of *d*-tubocurarine, whereas the intensity of its action is only about three times that of *d*-tubocurarine, indicates that the dimethyl ether compound is removed much more slowly than *d*-tubocurarine from its site of action in this species. That removal of both substances is partly effected by the kidneys is shown by the delayed recovery which follows ligation of the renal vessels. It is, however, clear that, in the rat with the kidneys eliminated, a mechanism exists for fairly rapid destruction or removal from the circulation of *d*-tubocurarine, but this mechanism does not operate, or operates very slowly, in the case of the other substance.

The dibenzyl and di-isopropyl ethers of *d*-tubocurarine iodide were prepared by methods similar to that described above. As judged by the *ED*50 and *LD*50 in the mouse, the dibenzyl compound possesses about one-third, and the di-isopropyl compound in preliminary experiments about one-half, of the activity of *d*-tubocurarine. In the rat and the rabbit, the dibenzyl compound exhibits about one-half the intensity of action of *d*-tubocurarine. In the rat, the dibenzyl ether gives no evidence of having an action more prolonged than that of *d*-tubocurarine at corresponding dosage-levels.

The dimethyl ether of *l*-bebeerine di-methochloride was prepared from *l*-bebeerine (from *Chondrodendrum platyphylum*) essentially by the method of King[1] (cf. Dutcher[2] and Brazil *et al.*[7]). The *ED*50 and *LD*50 of this compound in the mouse are approximately twice those of *d*-tubocurarine. The duration of paralysis in the mouse at two-thirds of the *LD*50 is approximately equivalent to that caused by *d*-tubocurarine at the same fraction of its *LD*50. In a Raventós preparation of the rat, 30 μgm. of the dimethyl ether of *l*-bebeerine dimethochloride reduced the tension of muscular contraction to the same extent as 10 μgm. of *d*-tubocurarine, but the effect of the bebeerine compound lasted four times as long. It is noteworthy that the dimethyl ether of *l*-bebeerine dimethochloride and its diastereoisomer, the dimethyl ether of *d*-tubocurarine iodide, both exhibit prolonged curarizing action in the rat as compared with *d*-tubocurarine.

We wish to express our thanks to the directors of Messrs. Allen and Hanburys, Ltd., for permission to publish this work; to Mr. C. J. Eastland for originally suggesting that the dimethyl ethers of *d*-tubocurarine and of *l*-bebeerine dimethochloride be synthesized and investigated; and also to Mr. S. H. Pegg and Miss P. B. Jacks for technical assistance in the pharmacological work.

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THE FLOW OF GLACIERS

A JOINT meeting of the British Glaciological Society, the British Rheologists' Club, and the Institute of Metals, held at the Institute of Metals on April 29, had as its main object the bringing together of glaciologists and those physicists and metallurgists who are interested in the theoretical problems of glacier flow. The exchange of experience and ideas between these two groups was a most stimulating feature of the meeting.

The meeting was in two sections. In the first part, with Sir Arthur Smout in the chair, Mr. Gerald Seligman, president of the British Glaciological Society, presented a film illustrating the methods of glacier research in the field used by the Jungfraujoch Glaciological Research Party in 1937 and 1938. The principal aim was to trace the transition of the tiny snow crystals which accumulate at the top of the glacier, first into the compacted glacier snow called 'firn', and then into the larger crystals of glacier ice. To illustrate this transition, slides were shown of photomicrographs taken between crossed nicols in which the growth of the individual crystals could be clearly seen.

The audience was introduced to the terrain investigated by a series of slides which, besides illustrating its purely geographical features, left no doubt about the beauty of the scenery in which the expedition worked. The film showed the construction of the expedition's 'cold laboratory', a small room excavated out of the glacier ice near the summit of the Jungfraujoch. This laboratory remained at a temperature of −4° C. throughout the summer months, and it was here that much of the work on the growth of ice crystals was done. There were, in addition, experiments on the distribution of velocity at the surface of the glacier and on the walls of a tunnel cut into the ice.

Mr. Seligman also described the work of the expedition last summer on the same subject. He pointed out that very large crystals (10 cm. or more in diameter) are only found in the 'dead' (non-flowing) ice left behind in patches when a glacier recedes. In flowing ice the crystals are much smaller (up to 1–2 cm. diameter). In his view, time and radiation (heat and light) are the main factors influencing the crystal size. The increase in crystal size from the head of a glacier to the snout is due to the fact that the crystals in the lower parts of the glacier are older than those higher up. To support this, he showed graphs giving the crystal sizes at the centres of the snouts in eleven glaciers plotted first against the length of travel and secondly against the mean angle of the glacier slope. The influence of radiation was shown by the fact that in the vicinity of an electric lamp in an ice cave the crystals were abnormally large. It appeared from Mr. Seligman's remarks that both grain growth and work recrystallization play a part in determining the size of the ice crystals. The large size of the crystals in dead ice is a consequence of the former process, and the abnormally rapid growth of new crystals near the end of the Upper Grindelwald Glacier is an example of the latter.

For the second part of the meeting, Dr. Richard Seligman took the chair, and the discussion on the flow of ice was opened by Dr. M. F. Perutz, who gave a short summary of the current theories. The main feature of the movement of a glacier, he said, is that it does not move rigidly, but that the centre

travels faster than the sides. Attempts made to treat the ice mathematically as a liquid of constant viscosity flowing in an evenly inclined channel have had some success, although there are also discrepancies. Lagally's development of Somigliana's theory has led to a relationship between the surface velocity at the centre of a glacier and its depth. Starting from the measured value of the velocity, the depth of the Pasterze in Austria, for example, has been calculated to be 280 m., a value confirmed by seismic soundings. In spite of this agreement, however, these theories have started from false premises, for ice is far from behaving as a liquid of constant viscosity. On the contrary, small differences in shear stress can produce large changes in velocity.

After referring to the importance of the large-scale thrust planes studied by Mr. W. V. Lewis, Dr. Perutz showed photographs taken by Dr. Winterhalter of Zurich of a thin sheet of ice placed between crossed nicols and loaded by sustained tension. The deformation of the constituent grains could be watched and there were indications of both gliding and mechanical twinning.

Dr. E. Orowan, who spoke next, took as his starting point the simplest laws of the theory of the plastic behaviour of crystalline bodies, and showed how many of the phenomena in glaciers, which at first sight appear to contradict common sense, can be understood from this point of view. Common sense in these matters is largely the accumulated experience of the behaviour of viscous liquids; but ice, like crystalline solids in general, is not a viscous but a plastic material. The flow of ice and that of viscous liquids corresponds to two distinct physical mechanisms and laws of irreversible deformation. However, the stress-strain relationship customarily used in engineering to describe the plastic behaviour of materials is not a complete description, because it omits time effects. The rate of change of strain with time under constant stress, that is, creep, is of primary importance in the flow of glaciers. Andrade has distinguished between two types of creep, the first dying away rapidly with time after the application of a stress, and the second being a permanent flow, the viscous creep. In glaciers, viscous creep seems the more significant part.

The idealized behaviour of ice on which Dr. Orowan bases his theory is that flow is negligible up to a certain critical stress, the yield stress. After that point a slight further increase of stress produces an extremely rapid increase of the rate of flow. The coefficients of viscosity 'measured' in experiments on glaciers are, he believes, of little physical significance. The three-dimensional nature of the stress system in large masses of ice is an important factor. Yielding depends on a critical value of the difference of two principal stresses being attained; pure hydrostatic tension or compression has no appreciable effect, contrary to a view often expressed by glaciologists.

The first simple problem Dr. Orowan discussed was that of a rectangular slab of ice resting on an inclined plane. Movement would be by shear in the lowest layer, and to each angle of slope would correspond one thickness of ice in plastic equilibrium. This implied that, when the ice reached a more steeply sloping part of the glacier bed, its thickness would be greater than the equilibrium thickness and this part of the ice would exert a pressure on the ice in front of it. This longitudinal pressure is the fundamental physical quantity in the flow; when it reaches a critical value, depending on the compressive yield stress of ice, longitudinal compression will occur. The observed thrust planes are a consequence of the compression; one cannot say exactly how they arise, but that they are a common phenomenon can be seen by attempting to clear away a fall of snow by pushing at it horizontally

The thrust plane is usually the plane next to the bed of the glacier. However, at sills, that is, at places where there is a sudden fall in the level of the bed, other thrust planes become geometrically possible. This, combined with the fact that the thickness of the ice, and hence its pressure, is less at the lip of the sill, relieves the bed in its neighbourhood of wear. On the steeply sloping downhill side of the sill, on the other hand, conditions are such as to favour wear, for the sliding will be concentrated in the lowest layer of the ice. This is the explanation of the steps so often seen in glacier beds.

Dr. Orowan went on to discuss the problem of a tall column of ice standing on a rigid horizontal plane. If the column were sufficiently high and slender, its weight would cause flow to take place at the bottom, and it would subside to an equilibrium height. In the Greenland ice-cap conditions are different, because, owing to the great extent of the ice mass, the shear stress acting on the lower strata impedes the flow there and at the same time tends to initiate flow in the upper strata. By the use of a simple theory of the process, the yield stress of ice can be calculated from the known height and width of Greenland. The figure so calculated, which is of the order of 1 kgm./cm.^{2}, is in agreement with the results of laboratory experiments. A warning is necessary, however, because even a slight slope (1 : 300) would be sufficient to explain the spreading without invoking any other influence.

In the general discussion which followed, Mr. W. V. Lewis expressed the pleasure felt by glaciologists and those concerned with the land forms produced by glaciers at the interest that physicists are beginning to show in the subject. The uplifting of the thrust planes at the ends of glaciers would naturally cause less grinding to occur there than elsewhere, and this explains very satisfactorily why glaciers erode hollows in their beds. The formation of the lakes which are such a striking feature of Alpine scenery is now no longer so mysterious. Answering a question by Sir Geoffrey Taylor, Mr. Lewis expressed the opinion that the remarkably regular series of curves seen on the surface of the Mêr de Glace, of which Dr. Perutz had shown a slide, are the result of successive overthrusts which have been afterwards drawn out into curves by the general flow of the ice. Several speakers referred to the slides Mr. Lewis presented, which showed the striking way in which large rocks and other debris, which had originally fallen into the Bergschrund at the head of the glacier, are later brought up to the surface on thrust planes lower down, and Mr. Webster Smith suggested an experiment in which coloured objects were to be carried down underneath the glacier. Dr. Perutz, however, thought that the slowness of the flow would make the experiment impossible. Mr. Webster Smith also emphasized the important influence of the varying hardness of the rocks constituting the glacier bed.

Dr. C. H. Desch drew a distinction between ice and metals by pointing out that, whereas ice expands on freezing, metals in general contract. That difference in behaviour should not be overlooked, and he suggested the use of bismuth at a few degrees below

its melting point for laboratory experiments. Bismuth, although brittle under certain conditions, can be extruded and, in addition, expands on freezing; the analogy with ice is therefore complete.

Mr. C. Gurney took up this point later by saying that, whereas the effect of hydrostatic pressure on the melting point is of opposite sign for ice and metals, the effect of uniaxial compression is always to lower the melting point, even in metals.

In reply to Dr. G. W. Scott Blair's suggestion that ice might be found to behave more like a Bingham solid than a material obeying St. Venant's law of plasticity, Dr. Orowan said that the existence of transient creep is evidence that ice is not a Bingham solid; on the other hand, the existence of creep in general shows that it does not exactly obey St. Venant's law either.

Dr. Perutz had observed that in Alpine glaciers the crevasses were never more than about 30 m. deep, and Mr. W. H. Ward pointed out that this depth could be correlated in order of magnitude with the known yield stress of ice.

The discussion provided a happy illustration of the benefit of applying the simplest of physical reasoning to a science as yet largely empirical. In the words of one of the contributors, it was "better to think exactly with simplified ideas than to reason inexactly with complex ones".

J. F. Nye

PROGRESS IN ARTIFICIAL ILLUMINATION

ALTHOUGH lip-service is commonly paid to the value of research, it is seldom that its direct benefits are so attractively displayed to the general public as has been done in the "Darkness into Daylight" Exhibition at the Science Museum, London, S.W.7. A visit to the Exhibition reminds one how very primitive were the means of artificial illumination only two centuries ago, while less than one hundred years ago the oil lamp was still the common form of lighting. We are all of us aware of the progress and achievements made during the past century. But how many realize that since only 1921 the efficiency of the ordinary 60-watt electric lamp has increased by 55 per cent while the cost has decreased by 75 per cent.

The exhibition has been organised by the Science Museum with the co-operation of the electrical industry of Britain, mainly to set forth the story of the development of electric lighting, but also to give a lead, and an example of the form of artificial illumination in the future.

A brief introductory section includes examples of some of the primitive forms of lighting used by early man—a hollow stone with fibre burning in animal fat, a wicker-work cage of fire-flies, sea-shell and oyster-shell lamps, a burning fish and a wick threaded into the body of a stormy-petrel are typical examples.

Passing from these primitive forms of lighting, a brief survey of the stages from the Middle Ages to the nineteenth century is made in a series of dioramas, showing the gradual changes brought about as candles and tallow-dipped rushes gave place to oil lamps and then in turn to the gas lamps of the last century. We can see the dawn of electric lighting with Swan's invention of 1878, its temporary eclipse by the Welsbach incandescent gas mantle and then the final triumph of the electric filament lamp.

The filament lamp has had a long career, and since its invention by Swan in 1878 and Edison in 1879 it has passed through innumerable stages of development. Swan had spent many years of research before he produced his carbon filament in 1878 and, incidentally, he laid the foundation stone of the rayon industry by his subsequent development of the squirted nitrocellulose filament in 1883. In stages, the carbon filament with its low efficiency of 2–3 lumens per watt gave way, first to the osmium filament, then to tantalum and finally to tungsten, when the difficulties of drawing tungsten wire had at last been overcome.

The tungsten-filament vacuum lamp had an efficiency nearly three times that of the carbon filament lamp, but to improve it still further a higher operating temperature was required. This resulted in an early blackening of the bulb, and although this could be overcome by filling the bulb with an inert gas, the heat lost by convection more than compensated for the gain until Langmuir's invention of the coiled filament in 1913. Still higher efficiencies were obtainable from the 'coiled-coil' filament invented soon after, but manufacturing difficulties prevented its introduction until 1934.

The efficiency of the modern filament lamp varies from the order of 12 lumens per watt for the smaller domestic sizes to about 25 lumens per watt for the largest projector lamps and, regarded as a source of artificial illumination, it must be agreed that the filament lamp is a remarkably cheap device. Indeed, as the visitor to the 'Darkness into Daylight' Exhibition is reminded at one stage, the average 60-watt lamp will burn for 1,000 hours at a cost, including that of the bulb, of only about 8*s*. 4*d*.; but were he by some whim or fancy to select candles as an alternative illuminant, he would need no less than 25,000 of them to give the same level of illumination for the same period and he would find himself faced with a bill of about £100!

As is perhaps inevitable, the accent of the Exhibition is on fluorescent lighting, and as one passes through this section one is forced to wonder whether the life of the filament lamp is doomed and whether it will eventually be replaced, like the oil lamp and the gas lamp before, by the low-pressure fluorescent tubes now being so widely used. Hitherto, these fluorescent lamps have only been available in lengths of 4 and 5 ft., but the recent announcement that 2-ft. tubes of 20- and 40-watt ratings will soon be introduced suggests a much wider application for domestic purposes. The fluorescence section of the Exhibition opens with a brief historical account of the discovery and developments which have contributed to the perfection of the modern tubes—the early observations of fluorescence, the Becquerel lamp of 1867 in which fluorescent materials were excited in a discharge tube, and the discovery in 1923 of a means of applying fluorescent materials to the walls of a mercury lamp. The stories of the search for a better colour spectrum, the first 'daylight' lamps and the finding of a single powder for producing a warm-white light are told by subsequent exhibits.

In imagination one is encouraged by a variety of fluorescent exhibits to regard such lamps as the lighting of the future. For industrial and commercial applications this indeed appears inevitable, but in spite of the three-fold improvement in efficiency and in spite of the three-fold increase in the average life, it still seems likely that the higher initial installation costs will reprieve the filament lamp for many years for ordinary domestic purposes.

In a brief review such as this, it is not possible to refer to the many stages of development in the various types of discharge lamps—the low-pressure sodium lamp with hot cathode, the low-, medium- and high-pressure mercury lamps, or to mention more than briefly the 5 kW. high-pressure water-cooled xenon arc now being shown to the public for the first time. Many of these developments are illustrated by exhibits and are described in greater detail with diagrams and photographs in the official handbook, "Darkness into Daylight", by W. T. O'Dea, which has been published in connexion with the exhibition (London: H.M. Stationery Office. 1*s.*).

The exhibition will remain open until September from 10 a.m. until 6 p.m. daily, and from 2.30 p.m. until 6 p.m. on Sundays; admission is free at all times.

PLANKTONIC COPEPODS AND HYDROCORALS OF THE JOHN MURRAY EXPEDITION

COLONEL SEYMOUR SEWELL'S account* of a large collection of free-swimming copepods from the Indian Ocean is an important critical study and a most valuable contribution to our knowledge of copepods in general.

In a previous paper (Sewell, 1920–32), seventeen species of free-swimming planktonic copepods were recorded from the northern part of the Indian Ocean, which up to that time were not known from any region other than the Atlantic Ocean or the Atlantic section of the Antarctic. The present collection contains twenty-one other species that so far have not been recorded beyond the Atlantic Ocean. As the author remarks, such a comparatively large number of deep-sea species that are common to the Atlantic and the Indian Ocean, but are at present unknown from any other region, indicates that there either is or has been a close connexion between the two regions. He has suggested (Sewell, 1940) that the explanation is to be found in the trend of the deep currents of the present day. He promises to deal later with the geographical distribution.

Well over two hundred species are recorded, with notes and remarks on most of them which are interesting and instructive. The new family Megacalanidæ is formed to include *Megacalanus*, *Bathycalanus* and *Brachycalanus*, all of which differ from the Calanidæ in several features and show a corresponding resemblance to the Centropagidæ.

Only one specimen of *Calanus finmarchicus* was found, a male, from the northern area of the Arabian Sea, 1,500–0 metres. It is rare in the Indian Ocean and it is suggested that its presence is explained by individuals being carried from the Atlantic Ocean round the Cape of Good Hope in the North Atlantic intermediate waters or the West Wind Drift, and then that they are caught up in the Sub-Polar Intermediate Current and so are carried northwards into the Arabian Sea.

Among the Sapphirinas it was found that *Sapphirina iris* was associated with the aggregated form of the salp *Pegea confederata*, some being inside. In this genus there were numerous cutaneous glands, opening on both dorsal and ventral aspects of the body in special positions in the different species. It is tempting to regard these as luminous organs, but the author does not wish to express an opinion on this point.

There is a long list of copepods with parasites both from surface-living and deep-dwelling species. This includes twenty-one species infested with the dinoflagellate *Blastodinium*. Comparing these with Chatton's seventeen species from the Mediterranean infested with *Blastodinium*, it is found that six are common to both lists.

Dr. Hjalmar Broch has found three new species in the four hydrocorals brought home by the John Murray Expedition to the Indian Ocean*. These include two new stylasters (*S.* (*Eustylaster*) *ramosus* and *S.* (*Eustylaster*) *lonchitis*), and one new *Crypthelia* (*C. clausa*), the fourth species being *Crypthelia stenopoma* Hickson and England. The two stylasters were from the Pemba Canal and the *Crypthelia* from the Maldives. It is interesting to note that in neither of these localities have Stylasteridæ been found before, and these reported localities of the John Murray Expedition are at the present day the most northerly localities of the Western Indian Ocean from which Stylasteridæ have as yet been found.

Another very interesting point is that whereas the two *Stylaster* species from the Pemba Canal have been collected in that zone of the bathymetrical region where the genus is known to be comparatively abundant in all seas, the localities of *Crypthelia* at the Maldives belong to the uppermost parts of its habitat, and its occurrence in these depths seems to be very scanty. The depth of 229 metres is the shallowest record of the genus, and *Crypthelia stenopoma* has hitherto only been taken in 1,300 metres or deeper in the Indo-Malayan Sea. *Stylaster ramosus* was abundant in two stations, its structure indicating that, like *Crypthelia stenopoma* and other Stylasteridæ, it is probably inhabited by commensal polychætes. The cirripede, *Pyrgoma*, is also commonly found in it.

* The Free-Swimming Planktonic Copepoda: Systematic Account. By Lieut.-Colonel R. B. Seymour Sewell. (The John Murray Expedition, 1933–34, Scientific Reports, Vol. 8, No. 1.) Pp. 304. (London: British Museum (Natural History), 1947.) 30*s.*

* Stylasteridæ (Hydrocorals) of the John Murray Expedition to the Indian Ocean. By Dr. Hjalmar Broch. (The John Murray Expedition, 1933–34, Scientific Reports, Vol. 8, No. 2.) Pp. 305–361+1 plate. (London: British Museum (Natural History), 1947.) 2*s.* 6*d.*

THE ELECTRICITY GRID IN GREAT BRITAIN

THE twentieth and last annual report of the Central Electricity Board has recently been published (Whitehead Morris, Ltd., 72–78 Fleet Street, London, E.C.4. 1*s.* net). Just short of attaining its majority, the Board loses its identity in the infant British Electricity Authority, this sturdy infant inheriting the Grid system of some 150 generating stations, capable of an output of nearly 12 million kilowatts. Appropriately appearing at about the same time as this report is an interesting and informative paper dealing with the British grid system ("Load Dispatching and the British Grid System"—A. R. Cooper, Institution of Electrical Engineers, March 18, 1948), a paper which is wider in scope than its title might suggest.

Mr. Cooper describes first the long-term planning associated with the extension of such a system; planning which, as the Central Electricity Board report makes clear, has had to yield to some extent

to the stern demands of economic necessity, so that there is likely to be a serious shortage of plant for an indefinite number of years.

When assessing the need for future extensions, an estimate is required of the availability of existing plant, and some striking figures are given indicating that the technical advance in operating conditions has carried with it a general reduction in availability, so that breakdowns are more frequent on modern than on older plant. Leading sources of trouble are said to be turbine-blading failures due to vibration, and alternator rotor failures due to copper distortion, both of which are the subject of intensive research. Also responsible for reduced availability, as well as reduced output capacity, is the supply of unsuitable and low-grade fuels to the boiler plant, a war-time inheritance which persists in spite of the very great increase in the price of fuel.

Proceeding to the short-term planning associated with the daily operation of the Grid system, the paper reveals that the system was originally designed to operate as seven independent sections, and it was not until the load position in some areas had become very grave in 1939 that it was decided to try the experiment of operating the whole of the system in parallel. This operation was successful and has been continued ever since, though the possibility of sequential tripping of lines, accentuated by the existence of only two interconnectors between the north and south of Great Britain, has demanded careful consideration.

After an interesting description of the sequence of events in the planning of a single day's operation of this complex system, from the nerve centre at national control in constant communication with the seven area controls, the paper concludes with a brief review of future developments. The most significant changes foreseen are the introduction of the gas turbine for peak-load working, and of atomic energy for base-load generation. Here it is of interest to turn again to the report of the Central Electricity Board, which is able to cite the arrangements the Board has made for the installation of two 15,000 kW. gas turbine sets, at Dunston and Stretford respectively; though the application of atomic energy remains a subject for study, and a hope for the future.

R. W. HAYWOOD

MOSSES AS SOIL INDICATORS

IT is pleasing to see that the attention of foresters is being directed to the mosses as indicators of soil conditions. H. Watson, forest officer instructor at the Benmore Forest School, Argyll, has produced an attractive booklet introducing this subject (Forestry Commission Booklet No. 1. Woodland Mosses. London: H.M. Stationery Office, 1947. 2*s*. net).

The brief introductory account of the life-history of a moss is followed by descriptions of twelve species likely to be encountered in afforestation areas. The descriptions are accompanied by 'turf' photographs to show the habit of growth in mass, and photographs of single shoots to illustrate the more detailed growth-form and include the salient features by which the species may be recognized in the field. There are also notes on the soil conditions favoured, especially as regards the degree of humus decomposition and soil acidity, and brief reference is made to the suitability or otherwise of the soil conditions indicated for afforestation purposes.

The mosses constitute a fascinating group of plants of which all too little is known. Many of them, after a little experience, can be recognized in the field by the naked eye or with the use of a hand lens, and type specimens may be kept dry in packets and soaked out again when required. Forest officers should be in a position to extend considerably our knowledge of the soil conditions indicated by the presence of particular moss species along the lines of the present booklet; and the recent production by Johnson and Sons, Ltd., of Hendon, N.W.4, of Universal and Comparator Test-papers for the measurement of *p*H values to within 0·3 *p*H, provides a very simple method for estimating the soil acidity with some degree of exactitude. Information of this kind would not only be of value to practical foresters, but would also extend our knowledge of this group of plants.

The British Bryological Society has recently asked its members to make observations on mosses with particular reference to times of production of capsules and reproductive organs in different carefully recorded localities and altitudes. The time of capsule production offers no difficulty, and in many cases the reproductive stage may be recognized by the opening of the antheridial cups, as illustrated in the booklet for *Mnium hornum*. It is to be hoped that foresters will be attracted by this aspect of ecology and that Forestry Commission Booklet No. 1 will be followed by others.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, May 24

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Anniversary Meeting.

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5.30 p.m.—Mr. E. W. Gilbert: "The Boundaries of Local Government Areas".

Tuesday, May 25

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Dr. E. R. Leach*: "Some Features of Social Structure among Sarawak Pagans".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. Brinley Thomas: "Migration and the British Commonwealth".*

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Annual General Meeting; Mr. J. K. Burkitt: "Proposed System in Instrumentation Symbols".

Wednesday, May 26

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Waldorf Hotel, Aldwych, London, W.C.2), at 12 noon.—Annual General Meeting.

ROYAL MICROSCOPICAL SOCIETY, SECTION OF INDUSTRIAL MICROSCOPY (at B.M.A. House, Tavistock Square, London, W.C.1), at 6 p.m.—Dr. K. M. Greenland: "Principles of Interference Films used in Optical Instruments".

Thursday, May 27

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Edward Salisbury, F.R.S.: "The Royal Botanic Gardens, Kew".

ROYAL STATISTICAL SOCIETY, RESEARCH SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. D. G. Champernowne: "Sampling Theory Applied to Autoregressive Sequences".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. A. Gouge: The 36th Wilbur Wright Memorial Lecture.

Friday, May 28

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the ROYAL SANITARY INSTITUTE, at the Royal Hall, Ripon Road, Harrogate), at 10 a.m.—Discussion on "The Cleaning and Sterilizing of Plant in the Food and Drink Industry" (to be opened by Dr. E. B. Hughes).

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (joint meeting with the INDUSTRIAL SPECTROSCOPIC GROUP, at 47 Belgrave Square, London, S.W.1), at 2.30 p.m.—Discussion on "The Application of Electron-Multipliers to Spectroscopy".

CHEMICAL SOCIETY (in the Washington Singer Laboratories, Prince of Wales Road, Exeter), at 4.30 p.m.—Prof. M. Stacey: "Advances in Immunochemistry".

BRITISH INSTITUTION OF RADIO ENGINEERS, MIDLAND SECTION (at the Technical College, The Butts, Coventry), at 6.30 p.m.—Mr. G. L. Hamburger: "An Automatic A.F. Response Curve Tracer".

CHEMICAL SOCIETY (joint meeting with the WERNER SOCIETY, in the Department of Chemistry, Trinity College, Dublin), at 7.45 p.m.—Dr. A. E. Gilliam: "Absorption Spectra as Chemical Tools".

Saturday, May 29

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, University Museum, Oxford), at 1 p.m.—Scientific Papers.

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (at the Tavistock Institute of Human Relations, 2 Beaumont Street, London, W.1), at 3 p.m.—"Social Change as a Problem for Social Psychology".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PROVINCIAL SPECIALIST ADVISORY OFFICERS and ASSISTANT ADVISORY OFFICERS in soil chemistry, the chemistry of animal nutrition, entomology, plant pathology and bacteriology—The Secretary, Ministry of Agriculture and Fisheries, 1–4 Cambridge Terrace, London, N.W.1, endorsed 'N.A.A.S.' (May 29).

SENIOR LABORATORY TECHNICIAN (male)—The Medical Superintendent, Glamorgan County Mental Hospital, Bridgend, Glam., endorsed 'Laboratory Technician' (May 29).

LECTURER IN MECHANICAL ENGINEERING, and a TEACHER OF ENGINEERING DRAWING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (May 29).

BACTERIOLOGIST—The Director, Freshwater Biological Association, Wray Castle, Ambleside, Westmorland (May 29).

ASSISTANT LECTURER IN AGRICULTURAL CHEMISTRY—The Registrar, Wye College, Wye, Ashford, Kent (May 29).

LECTURER/SENIOR LECTURER IN THE DEPARTMENT OF ANATOMY—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (May 29).

RESEARCH ASSISTANT TO THE READER IN PSYCHOLOGY in the Faculty of Education—The Registrar, The University, 46 North Bailey, Durham (May 29).

SENIOR LECTURER IN MATHEMATICS—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (May 29).

AGRICULTURAL ECONOMIST and ASSISTANT AGRICULTURAL ECONOMIST—The Professor of Agricultural Economics, University of Reading, 7 Redlands Road, Reading (May 30).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF AGRICULTURE (Animal Husbandry)—The Registrar, University College of Wales, Aberystwyth (May 31).

ASSISTANT LECTURER IN METALLURGY (with special qualifications in ferrous process metallurgy)—The Registrar, The University, Manchester 13 (May 31).

LECTURER IN PHYSIOLOGY—The Secretary and Registrar, The University, Bristol (June 1).

LECTURER ON THE STAFF OF THE ROYAL SOCIETY'S COMPUTING MACHINE LABORATORY, Department of Electrical Engineering—The Registrar, The University, Manchester 13 (June 4).

READERSHIP IN BIOCHEMISTRY at University College—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 9).

READERSHIP IN BIOLOGY at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 14).

OCCUPATIONAL PSYCHOLOGY RESEARCH OFFICER, Department of Scientific and Industrial Research, Wellington—The Official Secretary, High Commissioner for New Zealand, 415 Strand, London, W.C.2 (June 15).

READERSHIP IN MATHEMATICS at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 16).

LECTURER IN PHILOSOPHY—The Registrar, University College, Cathays Park, Cardiff (June 21).

SENIOR LECTURER IN POLITICAL SCIENCE, University of Melbourne—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (June 30).

BOTANIST (plant breeder) for research on the selection and breeding of *Hevea*, a BOTANIST for research and advisory work on botanical problems related to the cultivation of rubber, an ADVISORY OFFICER to undertake general agricultural advisory work, an AGRICULTURAL ENGINEER to investigate all aspects of the problem of mechanical cultivation in rubber, an ADVISORY OFFICER to undertake general advisory work in connexion with the cultivation of rubber by smallholders, and a CHEMIST to undergo a course of preliminary training in rubber latex technology and research at the Imperial Institute, at the Rubber Research Institute of Malaya—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, London, S.W.7.

HEAD OF THE NATIONAL COLLEGE FOR HEATING, VENTILATING, REFRIGERATION AND FAN ENGINEERING, a LECTURER IN FAN ENGINEERING, and a LECTURER IN HEATING AND VENTILATING ENGINEERING—The Clerk to the Governors, Borough Polytechnic, Borough Road, London, S.E.1.

ASSISTANT RESEARCH OFFICERS (chemists and physical chemists), and LABORATORY ASSISTANTS—The Director, British Paper and Board Industry Research Association, St. Winifred's Laboratories, Welcomes Road, Kenley, Surrey.

TECHNICIAN IN THE RESEARCH LABORATORY to work in the Department of Neurohistology—The Director of Research Laboratory, University of London Institute of Psychiatry, Maudsley Hospital Medical School, Denmark Hill, London, S.E.5.

SENIOR LABORATORY STEWARD to take charge of the laboratories in the Chemistry Department—The Secretary, Woolwich Polytechnic, Woolwich, London, S.E.18.

LECTURER (Grade II) IN THE DEPARTMENT OF P[illegible]—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4.

HEAD OF THE TEXTILE TESTING DEPARTMENT, an ORGANIC CHEMIST, and PHYSICISTS (7)—The Acting Secretary, British Rayon Research Association, 58 Whitworth Street, Manchester 1.

PHYSICAL CHEMISTS to build up a team to carry out fundamental research on the background physical chemistry of iron and steelmaking—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

MAN with good research experience for work on the physical chemistry of airborne dusts, especially those occurring in coal-mines—The Director, M.R.C. Pneumokoniosis Research Unit, Curran Works, Curran Road, Cardiff.

LIBRARIAN (with a good science degree, preferably in physics or chemistry)—The Director, British Boot, Shoe and Allied Trades Research Association, Satra House, Rockingham Road, Kettering.

TECHNICIAN IN THE PATHOLOGICAL DEPARTMENT—The House Governor and Secretary, Queen Mary's Hospital for the East End, Stratford, London, E.15.

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(not included in the monthly Books Supplement)

Great Britain and Ireland

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